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Status of Clockwork Chum Salmon Stock and Review of the Clockwork Management Strategy

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Abstract

This review examines the assessment of Inner South Coast (ISC) Clockwork chum stocks and the corresponding fishery management. The purpose of the paper is to provide: 1) an up to date stock-recruit analysis, including the large 1997 returns, for both Fraser and non-Fraser Clockwork stocks. The analysis focuses on wild stocks but an assessment of the enhanced component is also presented, 2) an updated assessment of escapement patterns, 3) an updated assessment of the Mission fry estimates and it's relationship to subsequent returns, 4) a retrospective analysis of in-season run size estimates in Johnstone Strait, and 5) a review of the fishery management (1983 through 1997) with respect to the effectiveness of the Clockwork management strategy.

Stock-recruit analysis was done on the 1959-1992 brood years for wild Fraser and non-Fraser Clockwork chum. Results show that for Fraser chum, the optimal harvest rate is approximately 45% which is almost identical to that found by Joyce and Cass (PSARC 92-02). However, unlike the earlier report, the optimal stock size was found to be 738,690 which is substantially greater than 485,320 estimated by Joyce and Cass. Further, evidence of density dependence was found for Fraser stocks that was not found in earlier work. For the aggregate wild stocks, the optimal harvest rate was 44% with optimum stock size calculated at 2.6 million and evidence for density dependence was also noted.

Chum escapement patterns and production has varied based on stock. For the overall aggregate production has increased. However, it would appear that not all areas have responded equally. Fraser River chum stocks have shown greater production and increased escapement relative to the other stocks and are driving the aggregate. Some stocks appear to be decreasing in spite of management and conservation actions. Specifically, escapement records to Upper Vancouver Island, Kingcome Inlet, Bond and Knight Inlets and Toba Inlet show declines in escapement levels. Factors such as lack of escapement enumeration effort and habitat issues may be responsible for the decline and these need to be explored in greater detail. Increased escapement levels for certain ISC chum stocks may be required to stop marked declines in escapement.

Heuristic analysis of the predictive ability of the Mission downstream fry data has shown that although the data correlates with subsequent stock size, it is still too variable to be considered a useful tool for prediction.

Six models were tested and analyzed as to their value for in-season stock size estimation. In general, no one model performed markedly better than any other model. Although run size estimates have been reasonably accurate in comparisons to the final run size, there have been a number of years when the in-season and final estimates have been significantly different. The current models are dependent upon the assumption of average migratory timing of the Clockwork chum stocks. In-season models based upon average migratory timing will under or over-forecast population abundance's because of run timing variability. Incorporating sex ratios with the best performing run model may improve forecasts over the best model without sex ratios.

The results from the review would indicate that overall the Clockwork management strategy has been successful in achieving a number of its objectives. Namely the strategy has allowed for limited commercial fishing in most years, increased wild escapement levels overall, and helped to increase our understanding of the optimal target escapement levels. When viewed from an aggregate viewpoint and taking the associated uncertainties into account, the Clockwork management strategy has worked reasonably well in meeting escapement and harvest rate targets and therefore should continue. That said, there remains significant concern over the level of escapement enumeration and accuracy of the escapement estimates upon which the Clockwork strategy and this stock status review depends. There is a need to standardize data collection methods to improve escapement estimates.

Résumé

Le présent examen porte sur l'évaluation des stocks de saumon kéta de la côte sud intérieure (ISC) gérés selon le modèle « Clockwork » et sur la gestion des pêches qui en est faite. Le document a pour objet de fournir : 1) une analyse stock-recrutement à jour, y compris des importantes remontées de 1997, pour les stocks du Fraser ou d'autres cours d'eau gérés selon le modèle Clockwork, l'accent est mis sur les stocks sauvages, mais une évaluation de la composante mise en valeur est aussi présentée; 2) une évaluation à jour du régime des échappées; 3) une évaluation à jour du nombre estimé d'alevins dans la Mission et des rapports avec les remontées ultérieures; 4) une analyse rétrospective des estimations en cours de saison de l'effectif des remontées dans le détroit Johnstone et 5) un examen de la gestion des pêches (de 1983 à 1997) portant sur l'efficacité de la stratégie de gestion Clockwork.

L'analyse stock-recrutement a été effectuée pour les années de ponte 1959-1992 des saumons kéta sauvages du Fraser et d'autres cours d'eau gérés par modèle Clockwork. Les résultats montrent que, pour le kéta du Fraser, le taux de récolte optimal s'élève à 45 % environ, soit pratiquement à la valeur déterminée par Joyce et Cass (CEESP 92-02). Mais au contraire du rapport précédent, l'effectif optimal du stock s'élevait à 738 690, ce qui est de beaucoup supérieur à l'estimation de Joyce et Cass de 485 320. En outre, une dépendance envers la densité, qui n'avait pas été décelée antérieurement, a été notée pour les stocks du Fraser. En ce qui a trait à l'ensemble des stocks sauvages, le taux de récolte optimal était de 44 % pour un effectif optimum de 2,6 millions et l'on a aussi noté une dépendance envers la densité.

L'allure des échappées du kéta et la production ont varié selon les stocks, mais la production totale s'est accrue. Par ailleurs, ce phénomène n'a pas été noté également dans toutes les zones. Les stocks de kéta du Fraser sont ceux dont la production et les échappées ont le plus augmenté et ce sont eux qui donnent l'allure à l'ensemble. Certains stocks semblent être en déclin en dépit des mesures de gestion et de conservation adoptées. Plus précisément, on a noté des échappées records pour Upper Vancouver Island, mais un déclin pour Kingcome Inlet, Bond et Knight Inlets et Toba Inlet. Certains facteurs, comme l'insuffisance des efforts consacrés au dénombrement des échappées et des problèmes relatifs à l'habitat, peuvent expliquer ce déclin et devront être examinés de façon plus approfondie. Il pourra s'avérer nécessaire d'accroître les échappées de certains stocks de kéta de la ISC pour mettre fin au déclin marqué des échappées.

Une analyse heuristique de la capacité prévisionnelle des données sur les alevins en aval de Mission a montré qu'en dépit d'une corrélation avec l'effectif ultérieur du stock, ces données étaient trop variables pour servir d'outil de prévision utile.

Six modèles ont été testés et analysés dans l'optique de leur valeur pour l'estimation de l'effectif du stock en cours de saison. De façon générale, aucun modèle ne s'est montré supérieur aux autres. L'effectif des remontées estimé s'est avéré raisonnablement exact par comparaison à l'effectif final, mais on a noté plusieurs années au cours desquelles l'estimation faite en cours de saison et l'estimation finale différaient de façon significative. Les modèles actuels sont dépendants de l'hypothèse d'une période de migration moyenne des stocks de saumon kéta utilisée pour le modèle Clockwork. Les modèles d'estimation en cours de saison fondés sur le moment moyen de la migration sous-estiment ou surestiment l'effectif à cause de la variabilité du moment de la remontée. Le fait d'incorporer le rapport des sexes au modèle le plus performant pourrait permettre d'améliorer les prévisions en comparaison avec le meilleur modèle sans le rapport des sexes.

Les résultats de l'examen indiqueraient que, de façon générale, la stratégie de gestion Clockwork a donné de bons résultats et permis d'atteindre plusieurs des objectifs fixés. Plus précisément, la stratégie a permis de limiter la pêche commerciale au cours de la plupart des années, d'accroître le total des échappées de poissons sauvages et de mieux connaître les niveaux d'échappées cibles optimaux. Si l'on envisage l'ensemble des résultats et prend en compte les incertitudes connexes, la stratégie de gestion Clockwork a donné d'assez bons résultats en ce qui a trait à l'atteinte des cibles en matière d'échappées et de récolte. Elle devrait donc être maintenue. Cela dit, le dénombrement des échappées et l'exactitude de leur estimation sur lesquels reposent la stratégie Clockwork et l'examen de l'état du stock demeurent sources de préoccupations. Il y a lieu de normaliser les méthodes de collecte des données afin d'améliorer l'estimation des échappées.

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1.0 Introduction

Chum returning to spawn in their natal streams in the Mainland Inlets, Johnstone Strait, Strait of Georgia, and the Fraser River migrate primarily through Johnstone Strait. Because of their overlapping timing and migration route, chum from these areas are grouped into a single unit for management purposes, commonly referred to as the Inner South Coast (ISC). More than 400 distinctive populations of chum originate in the ISC. However, 45 of these populations are responsible for 85% of the chum production, with the Fraser River having the largest populations (Anderson and Beacham 1983).

The ISC is divided into fifteen major geographic regions: 1) Seymour to Belize Inlet, 2) Upper Vancouver Island, 3) Johnstone Strait, 4) Mid Vancouver Island, 5) Lower Vancouver Island, 6) South Vancouver Island, 7) Kingcome Inlet, 8) Bond to Knight inlets, 9) Loughborough to Bute inlets, 10) Toba Inlet, 11) Jervis Inlet, 12) Howe Sound/Sunshine Coast, 13) Burrard Inlet, 14) Fraser River, and 15) Boundary Bay (Figure 1.1).

A subgroup of ISC chum stocks forms the Inner Study Area or Clockwork chums. The ISA includes chum salmon stocks spawning along the east and west coasts of Johnstone and Georgia straits from the north end of Vancouver Island to Boundary Bay and Saanich Inlet to the south. The ISA does not include chum stocks in Seymour to Belize Inlet (Area 11) in the north and the southern portion of South Vancouver Island (Areas 19 and 20) because these stocks are not harvested in Johnstone or Georgia Straits.

1.1 The Fisheries

ISC chum stocks are divided into two groups based on run timing, the Summer and Fall runs. Summer chum migrate in June, July and August and spawn in September and early October while Fall chum migrate in September, October and November and spawn from October to January (Salo 1991). Only the Fall run stocks are actively managed in mixed stock fisheries. The Summer run stocks are managed in terminal areas where local surpluses are harvested. The major inside Summer run stocks are in Bute and Kingcome inlets.

Chum salmon migrating through Johnstone and Georgia straits are subjected to several fisheries. The first major fishery on ISC chum stocks occurs in Johnstone Strait (Statistical Areas 12 and 13), approximately 110 km in length, through which chum must pass en route to their spawning grounds. Here chum are concentrated during their inshore migration and are subjected to intensive net fisheries (seine and gillnet). The catch in this fishery has ranged from 15% to 80% of the total commercial catch of ISC stocks between 1980 and 1996 and averaged about 60% of the commercial catch or 1.0M (million) chum per year between 1990 and 1996.

The terminal fishery at Qualicum Bay harvests predominately enhanced chum stocks from the Big Qualicum, Little Qualicum and Puntledge River hatcheries. The catch in the Qualicum fishery has ranged from 10% to 80% of the total commercial catch between 1980 and 1996 and averaged about 20% of the commercial catch or 270,000 chum per year between 1990 and 1996.

Other areas that have terminal fisheries are the Cowichan, Goldstream, Nanaimo and the Nimpkish rivers, and in Jervis and Bute inlets. These fisheries target mainly on local stocks.

The Fraser River fishery (Statistical Area 29) includes the 80 km of the Fraser River downstream from Mission, the estuary and the adjacent waters of the southern portion of Georgia Strait. The Fraser River fishery harvests predominately enhanced chum stocks from the Harrison, Chehalis, Inch, Stave, and Chilliwack/Vedder systems. Canadian chum (primarily of Fraser River origin) are also harvested in U.S. fishing areas. The commercial catches in Area 29 and the U.S. areas are of about equal magnitude and represent about 5% and 8%, respectively, of the total commercial ISC chum catch.

Chum salmon are important to aboriginal peoples for food, ceremonial, and cultural purposes. In the early 1990s, DFO initiated greater access to the salmon resource for First Nations through the Aboriginal Fisheries Strategy. This initiative resulted in greater participation by First Nation groups in ISC chum fisheries.

Historically, the recreational sports fishery has harvested very few chum salmon. The inclement weather conditions during the late return timing of chum salmon and that they are less desirable as a sports fish have contributed to the lack of interest in this species. However, the recent low abundance of coho and chinook and the development of appropriate recreational chum fishing techniques have resulted in a small but growing sports fishery for chum in Johnstone Strait.

1.2 Resource Status

In the late 1800s and early 1900s chum salmon were considered a less desirable species and therefore were of less concern to the commercial fishery. Chum fisheries of British Columbia assumed commercial importance during the war of 1914 -18 (Hoar 1951). Catch statistics for a 31-year period, 1917 to 1947 shows an increase in chum catches due to the decrease in sockeye catches (as a result of the Hell's Gate slide). Declines in chum abundance were experienced in the early 1940s and it seems highly probable that total returns were low in the early 1920s and 1930s. Since 1939 the contribution of chum to the catch has steadily increased.

Catch of ISC chum stocks declined sharply between the early 1950s and the mid-1960s while escapements were stable at low levels (Figure 1.2). The rapidly declining stock size in the early 1960s prompted the complete closure of commercial chum fisheries in 1965 and 1966. The stock then rapidly recovered, so that 1973 recorded a catch of just over 3.0M chum and an escapement of nearly 1.6M. Catches again declined between 1974 and 1981, with higher catches in even-numbered years than in odd-numbered years (Beacham 1984). To address the problem of rebuilding the wild component of chum production and to provide the maximum long-term benefit to industry, a "Clockwork" management plan was implemented in 1983. In addition, major enhancement efforts commenced in the 1980s, and began to show significant returns by 1985.

1.3 Enhancement

The first major Department of Fisheries and Oceans chum enhancement project was designed to increase the freshwater survival of chum salmon by building a flow control and small artificial spawning channel facility on the Big Qualicum River in 1963. This spawning channel (Channel #1) was converted into a chum rearing channel in 1966 and finally rebuilt into a coho rearing channel. A new spawning channel with a capacity of 34 million eggs was built in 1967 (Fraser et al, 1983). The Salmon Enhancement Program's (SEP) first spawning channel was built on the Little Qualicum River in 1979. It had a capacity of 75 million chum eggs.

SEP piloted the Japanese style of chum enhancement at the Thornton Creek pilot hatchery in 1976-77. A successful program at Thornton led SEP to use the Japanese style in the design of all its major chum hatcheries. The technique involves the groundwater incubation of eggs in bulk incubators usually called modified Atkins boxes or freestyle boxes. Prior to hatching, eggs are usually placed on Vexar trays above a layer of gravel or other media in shallow concrete raceways known as keeper channels. Upon hatching, fry drop through the trays into the gravel. Fry migrate directly from the keeper channels into concrete raceways for rearing. Rearing is also performed in earthen channels and seapens. By utilizing the temperature advantage of groundwater, fry can be reared for 30-40 days in freshwater to approximately 1.0-1.5 g at release at close to the normal wild migration time. This size advantage was expected to double survival compared to unfed wild fry.

Chum facilities are situated in locations where terminal fisheries can harvest enhanced chum stocks at high rates without over-harvesting non-enhanced stocks. All major Mid Vancouver Island stocks (Big Qualicum, Little Qualicum, and Puntledge) and all major Fraser River chum stocks were enhanced (Chilliwack, Chehalis, Harrison, Inch, Stave, and Alouette). All Harrison stocks including Chehalis, Harrison, and Squakum, and Weaver of various run timings were initially enhanced and releases went back their streams of origin. By 1986 releases were only made into the Chehalis River from Chehalis Hatchery. Chehalis hatchery stock originated from transplants of all of the various Harrison stocks. There are a number of other Community Involvement facilities producing chum (Powell River, Sliammon, Kanaka Cr., and Alouette) which are not included in this analysis because of limited marking.

1.4 Clockwork Management

Prior to 1983 the stated management approach for ISC chum involved harvesting all chum salmon in excess of an escapement goal for all stocks combined. In practice, this approach was difficult to implement because of differences in run timing and productivity with the result that some stocks were over-harvested while other stocks were potentially under-harvested.

The Johnstone Strait Clockwork Management Strategy was implemented in 1983 (Hilborn and Luedke 1987). The primary objective of the Clockwork was to rebuild ISA wild chum stocks within 12 to 15 years to the target escapement level of 2.5M chum (including 700,000 Fraser River chum) by controlling the overall harvest rate. The plan allows for limited fishing at low stock abundance, thereby stabilizing the annual catch. Incremental harvest rates for the marine fisheries are set at 10%, 20%, 30% or 40% depending upon the run size. For fishery management planning purposes, a pre-season forecast of abundance is used to determine the expected harvest rate. The harvest rate is adjusted if in-season information suggests the pre-season forecast was incorrect.

The Clockwork allows both the catch and the escapement to increase with increasing total run size up to a maximum harvest rate of 40%. A Fraser River Clockwork management plan was implemented in 1987 (Gould et al. 1991) to provide management goals and fishing limits for the harvest of Fraser River chum, independent of the Johnstone Strait fishery.

The Clockwork has been reviewed periodically and a number of changes adopted. The changes were adopted for a variety of reasons, such as increasing enhancement levels or as a means to increase the probability of achieving the wild escapement goal at lower run sizes. Fourteen years of chum salmon returns have occurred since the Clockwork Management Strategy was implemented and it is time for an in depth review of chum stock status and management strategy. The review provides: 1) Trends in chum Clockwork stock and enhanced production; 2) Status of escapement estimates; 3) An up-date stock-recuit analysis, including the larger returns for 1997, for both the Fraser and non-Fraser Clockwork stocks and for both the wild and enhanced components; 4) The utility of the Mission fry estimates in it's relation to sebsequent returns; 5) A restrospective analysis of in-season run sizes in Johnstone Strait; and 6) A review of the fishery management, 1983 to 1997, with respect to the effectiveness of the Clockwork management strategy.

2.0 Data Sources

Data used in this document are estimates of annual catch from test, commercial and Native fisheries, escapement estimates from wild and enhanced systems and estimates of stock composition obtained from GSI. The following is a summary of the sources and methodology for the collection of these data. Inconsistencies or possible sources of error are noted where appropriate.

Data for the analyses was extracted from the Chum Clockwork System Database. This is a Microsoft Access Database system that contains the necessary information for clockwork chum stocks (including Fraser River stocks) that can be easily extracted in report form or as spreadsheet files for import into Microsoft Excel for analysis or further export.

Data from Area 11 (Seymour and Belize Inlets) and Areas 19 and 20 (Southern Vancouver Island) and for Summer chum were not included in the analyses relating to Study Area or Clockwork Chum. Escapement data from these areas was included in the Stock Status Review for completeness.

2.1 Catch

Estimates of ISC chum catch are made for Canadian and U.S. commercial fisheries as well as Native fisheries. The catch of sport caught chum is considered insignificant but has been increasing in recent years.

Canadian commercial and test fishery catches are from sale slip records. All Canadian commercial catches were obtained from the Commercial Salmon Catch Database maintained at the Pacific Biological Station. U.S. commercial catches are from the Washington Department of Fisheries/Tribal Catch Database. Estimates of Canadian Native food and commercial catches are from British Columbia Catch Statistics, Bijsterveld and James (1986) and MacDonald (1987).

2.2 Escapement

Estimates of total escapement can be divided into two components; fish spawning in naturally occurring or rehabilitated spawning grounds and fish returning to a hatchery facility. Official escapement estimates (spawning counts and hatchery returns (BC16's)) for chum salmon streams have been recorded since 1953 and are available in the SEDS computer database at the Pacific Biological Station. There are numerous exceptions, especially in recent years, where an alternative data source has been used, as there is no BC16 report. Additional data was obtained from local fisheries offices, Fraser River Action Plan, Fisheries Management Group (DFO 1996) and SEP escapement data files.

2.3 Target escapement and spawning capacity levels

The Pacific Region Salmon Stock Management Plan (DFO 1988) contains target escapement levels for the major regions within the Inner South Coast. A historical review of chum salmon data for the years prior to 1985 by the Pacific Salmon Commission Joint Chum Technical Committee (1988) contain estimates of spawning capacity for Inside Study Area chum stocks associated with the chum Clockwork Management Strategy.

2.4 Enhancement Contribution

Enhanced contributions from major facilities is based on marking a portion of the fry released with an adipose clip and coded-wire tag (Ad-cwt) or a ventral fin-clip with or without an adipose clip (MFC), and recovery of these marks in the commercial fishery and escapement. Marked fry are enumerated individually at marking. Big and Little Qualicum and the Chilliwack releases have been marked with finclips and Puntledge, Chehalis, Inch, and Chehalis with Ad-cwt's. Unmarked fry represented by the mark are enumerated by subtracting egg and fry mortalities from the egg number which is usually calculated using electronic egg counters. Since egg and fry mortality generally is less than 10%, fry enumeration is considered to be very accurate. Not all release groups are represented by a mark. Contributions for those groups are estimated by associating them with a marked release group with a similar size and release timing. Unfed unmarked release groups were usually given half the survival of an associated fed release group. All chum release data is maintained in the Mark Recovery Program (MRP) database on the VAX at the Pacific Biological Station. Kuhn et al, 1988 (P. 6-10) describes the release data in detail.

Sampling of the commercial net catch has been carried out in specific catch areas under contract to the Stock Assessment Division, Mark Recovery Program. Sampling of the ISC catch usually occurs at processors in Vancouver. The catch is usually sampled on conveyor belts as the packers are unloaded. No sampling is performed on troll, sport, native, or U.S. catches. Troll and sport catches are estimated to be less than 2% of the total catch. Catches by native and U.S. fishers can be considerable, especially for Fraser stocks. From 1985-1997 this would add an estimated 35% to enhanced catch and 10% to total enhanced Fraser stock. Not all weeks or areas were sampled consistently. For some unsampled weeks the mark rate from the previous or subsequent week was used to estimate contribution. Contributions are considered to be a minimum estimate of total enhanced contribution.

Except for Chehalis natural spawners, SEP escapement data is considered quite reliable. Big Qualicum counts 95% of the chum through a fence and samples all fish in the spawning channel and a portion of the river. All chum migrating into the Little Qualicum spawning channel have been regularly enumerated and sampled for marks; the river is visually enumerated and sampled for marks. All other enhanced stocks, except the Stave River, have an extensive migration (rack) into the facilities and these are accurately counted and intensively sampled. In addition, these facilities also estimate escapement and sample for marks on the spawning grounds. Puntledge Hatchery conducts a regular visual enumeration, brood stock collection, and dead pitch on the river. Tag and recovery programs have occurred in 1989-91, 94 on the Stave River and in 1986,1996, and 1997 on the Chilliwack River. In subsequent years the Stave River has been enumerated weekly by helicopter and AUC (Area-Under-the-Curve) estimates are made to estimate escapement. Extensive dead pitches have occurred on the Stave for mark sampling. Chilliwack estimates escapement by using the dead pitch recovery rate from the 1986 tag and recovery program and a comparable effort dead pitch in subsequent years adjusted for water conditions. Chehalis Hatchery does a visual escapement estimate on the Chehalis River. Inch Hatchery conducts a below the fence dead pitch which recovers at least 90 % of the spawned chums in this groundwater fed stream. More detailed data on escapement enumeration is located in PSARC report S90-11. Rack returns may be used for broodstock or be subject to ESSR (Escapement Surplus to Spawning Requirements) and sold to the highest bidder or supplied to the local native community for subsequent sale. These rack returns are not included in the exploitation rate computed here but are included in the escapement.

Up to and including the 1994 return year, contributions had been calculated on Apple Magicalc and IBM Framework spreadsheets, some of which had been converted to Excel. Summaries of this data were included in an interim chum Microsoft Access SEP Evaluation database. A new Access database currently calculates catch and escapement contributions from the 1995 return year but summaries of the previous data are also maintained in this database. Catch contributions for 1997 have not been added to the database, the data is from preliminary in-season Excel spreadsheets. Escapement contributions for 1997 are included for all facilities except Puntledge. Contributions are adjusted upwards for an estimated 30% mark mortality based on years of extensive sampling at Big Qualicum where all fry migrants were enumerated and mark returns were extensively sampled. This estimate of mark mortality was confirmed from a 1989 brood release of marked chum into Cook Creek, a barren stream on the West Coast of Vancouver Island, (D.Bailey, unpublished data). More detailed information on how these contributions are calculated are contained in previous PSARC reports S88-11 (Bailey and Plotnikoff, 1988), S89-24 (Bailey and Plotkikoff, 1989), and S90-11 (Bailey et al. 1990).

2.5 Stock Identification

Estimates of Fraser River and Canadian non-Fraser stock groups were estimated through the use of GSI methods (Hop Wo et al., 1991). GSI samples have been collected from 1982 through 1993, and 1996 in all major intercepting fisheries. For years without samples estimates of Fraser River/Canadian non-Fraser River contribution were estimated by weekly average GSI data for each intercepting fishery. Chum salmon caught in the Fraser River terminal fishery are assumed to be 100% Fraser River origin. Since 1980, all Fraser River terminal fisheries targeting on chum salmon have occurred in the River portion of Area 29.

Calculation of the Fraser River portion in U.S. fisheries is made using fixed percentages of 32% for U.S. Areas 4B, 5 6C, 56% Areas 7 and 90% Area 7A. These estimates were based upon previous tagging studies. GSI sampling supports the averages.

2.6 Age

Fish scales used to determine age structure are derived from catch (commercial and test fisheries) and escapement samples. Fish age was determined from annular ring counts. For example, a chum salmon scale with three angular rings would be classified as a 4-year old fish. In the European system this fish would be designated as a 0.3.

2.7 Effort

Effort information is recorded as boat days for commercial fisheries and number of sets for the test fisheries. Effort counts were obtained visually via overflights during the operation of the commercial fishery.

2.8 Test Fisheries

The final primary source of data used in this report was obtained from two seine vessels operating under charter to DFO within Johnstone Strait. The program was initiated in 1965, primarily in years of low expected abundance. Starting in the late 1970's the program has begun in late September and continued through until early November. Each vessel is required to make six test sets per day among 40 possible locations within Johnstone Strait. Full descriptions of this operation can be found in Hop Wo et al. (1993) and are not repeated here.

3.0 Trends in Chum Clockwork Stock and Enhanced Production

3.1 Enhanced juvenile releases

Figure 3.1 and Table 3.1 shows the estimated ISC fed (mostly Fraser hatcheries) and unfed (mostly Non-Fraser flow control and spawning channel) chum releases from major enhancement facilities. As new SEP facilities came online from 1980-1983 in the Fraser, the number of fed releases increased almost five times from an average of 6.9 million in the 1978-81 broods to 33.4 million in the 1982-86 broods. Unfed fry releases increased more slowly from an average of 55.1 million for the 1980-83 broods to 65.1 million for the 1982-86 broods. However, poor escapements in 1995 through 1997 to Big and Little Qualicum dramatically reduced unfed fry releases. In 1985, the Fraser River fishery management group asked SEP to concentrate chum enhancement on the mid-timing Fraser component. As a result of adopting this strategy, the Chehalis Hatchery could not double use its ponds for rearing. Fry production was reduced from an original target of 13.0 million fry to 7.8 million fry. Inch and Chilliwack have subsequently reduced fed fry production because of higher priorities for chinook. Fed fry production was reduced from an average 33.4 million for 1982-86 broods to 24.1 million for 1987-97. The latest fed fry target of 15.6 million is only 46% of the original target of 28.8 million. Unfed fry release targets have remained largely the same. Because of these fed fry reductions, enhanced contribution to the Fraser River has not been as high as originally intended and should continue to decrease as progeny from the current targets return. Inside Non-Fraser chum production should remain stable.

3.2 Enhanced contribution to Canadian net catch and escapement

Tables 3.2.1 to 3.2.3 show the estimated contribution of major SEP facilities to the net catch, escapement, and total stock from the 1980 return year to 1997. Data for 1997 are preliminary. Catches have averaged about 575,000 for ISC stocks from 1985-94 return years (when facilities were in full operation) of which most originated from the Non-Fraser stocks (473,000-82%) compared to Fraser stocks (102,000-18%). This is the result of the much higher Non-Fraser releases and a higher exploitation rate as a result of the Area 14 terminal fishery. Poor survivals in the 1995-97 return years dramatically reduced catches. Escapements during the same 1985-94 time period have averaged 396,000 for the ISC stocks and 209,000 (53%) for Non-Fraser stocks versus 187,000 (47%) for Fraser stocks. Escapements decreased 40% for the 1995-97 return years. Total enhanced stock for the 1985-94 time period has averaged 971,000 for the ISC stocks of which 681,000 (70%) are from Non-Fraser stocks and 290,000 (30%) from Fraser stocks. This decreased to 120,000 for Non-Fraser stocks and 148,000 for Fraser stocks for the 1995-97 return years. Concerns about the trend to lower production for the 1995-97 return year were somewhat allayed with the near record chum returns in 1998.

Figure 3.2.1 and Table 3.2.4 shows the prevalence of enhanced fish in the catch and escapement for Non-Fraser and Fraser stocks. For the 1980-97 return years 33% of the average catch and 19% of the average escapement for the Non-Fraser stocks were estimated to be of enhanced origin. This rises to 38% and 21% for 1985-94 when enhanced stocks were most prevalent. The enhanced contribution in the catch is higher than the escapement because of the concentration of the Johnstone Strait harvest on mid-timing enhanced stocks and the fact that the terminal Area 14 fishery only targets enhanced stocks. Comparable numbers for the Fraser stocks were 23% of the catch and 15% of the escapement for 1980-97 and 34% and 22% for 1985-94. Catch numbers are likely higher because of the concentration of harvest in Johnstone Strait and the Fraser River on mid-timing enhanced stocks. Reductions of the enhanced proportion in the 1995-97 Non-Fraser catch are probably due to the drastically reduced harvest in those years, particularly in time periods and terminal areas where enhanced fish are usually present. The reduced enhanced proportion in the 1995-97 Fraser escapement is directly correlated with the large increase in Harrison wild escapements which increased from an average of 124,000 in 1980-89 to 825,000 in 1994 and 1,256,000 in 1995 subsequently dropping to 496,000 in 1996.

Significant numbers of enhanced origin chum spawn naturally. Table 3.2.5 gives some indication of the numbers in recent years. Unfortunately the data is not electronically available prior to 1992. The data shows that significant numbers spawn naturally and have over the years contributed substantially to rebuilding depressed chum escapements, especially in streams like the Stave where all returning chum spawn naturally.

3.3 Enhanced exploitation rates

Table 3.3.1 shows the enhanced stocks net catch exploitation rate, which has averaged 57% for the 1985-94 return years. Non-Fraser stocks have a substantially higher exploitation rate at 67% versus 32% for Fraser stocks. The Non-Fraser enhanced exploitation rate is higher than the overall Non-Fraser wild + enhanced rate of 54% because harvest is generally concentrated on the more productive mid timing enhanced stocks in Johnstone Strait and because the terminal fishery in Area 14 is concentrated only on enhanced stocks. Addition of enhanced contribution to U.S., sport, and native catches would probably increase the Fraser enhanced exploitation rate from 32% to about 43%. This is higher than the enhanced + wild exploitation rate of 32% probably because harvest is concentrated on the mid timing enhanced stocks rather than the late timing wild stocks. Exploitation rates dropped to low levels in 1995-97 return years, reflecting poor returns of both wild and enhanced stocks.

The exploitation rates of among Non-Fraser facilities are similar but Puntledge and L.Qualicum are slightly lower than Big Qualicum, probably because of earlier timing than Big Qualicum. Terminal harvests tended to occur after escapement targets were attained. Fraser facility exploitation rates are similar except for Stave and Inch whose timings are earlier and later respectively than other enhanced stocks.

Table 3.3.2 shows the distribution of enhanced chum to the catch and escapement recovery areas. For the 1980-97 return years Non-Fraser enhanced stocks have averaged 20% harvest in

Johnstone Strait plus a terminal harvest of 32% in Area 14. This increases to 30% and 36% respectively for the 1985-94 returns years when enhanced fish were most prevalent and stocks were strong. Because most of the Non-Fraser enhanced releases were marked with the same fin-clips as those used at enhancement facilities on the outside of Vancouver Island and in the North, any Non-Fraser stocks caught in Area 2-10, 21-27 could not be identified. For the 1980-97 return years Fraser enhanced stocks were harvested at a rate of 17% in Johnstone Strait, 3% in Area 14-20, and 5% in Area 29 fisheries. For the 1985-94 return years this increases to 24%, 2%, and 6% respectively. A small number were harvested outside of these areas. Chehalis, Inch, and Stave were coded-wire tagged and tags have been recovered at low rates (< 1%) during sampling in the Nitinat (Area 21) and Conuma (Area 25) fisheries. Some have also been recovered in Ad-cwt sampling in Alaska and Northern B.C., although in very low numbers.

3.4 Enhanced fry-to-adult survivals

Figure 3.4.1 and Table 3.4.1 shows the fry-to-adult survivals for enhanced fed and unfed releases from ISC chum. Survivals of fed fry from Non-Fraser facilities have generally been slightly higher than from Fraser facilities. If estimated contributions from U.S. and native catches are added to the Fraser survivals, survivals would likely be about 10% higher at about 1.2 %, putting them in the same range as the Non-Fraser facilities. This is still lower than the target survival of 1.5% which is based on a doubling of unfed survival. Unfed fry survivals have averaged 0.70% for Big Qualicum and 0.47% for Little Qualicum for the 1978-92 broods. Why survival is different between these two stocks is presently unknown. Big Qualicum survival is based on releases from the river as well as the spawning channel while Little Qualicum is based only on spawning channel releases, but previous data at Big Qualicum showed no difference in survival between Big Qualicum channel and river releases (Fraser et al. 1983). The previous 1959-77 brood average Big Qualicum unfed survival was 0.50%, substantially less than the subsequent average survival.

Annual survival is extremely variable ranging from a low of 0.29 % to a high of 2.69% for Fraser fed fry and a low of 0.03% to a high of 1.17% for Non-Fraser unfed fry. Coupled with the variability in freshwater survival for wild stocks this variability makes forecasting chum returns very difficult.

Competition with Fraser pinks may be a factor in survival of enhanced Fraser chum fry. Every Fraser enhanced chum stock has a higher average survival in the even years when pinks are not present than in the odd years. For the Fraser enhanced stock in total, average survival in the odd years was 0.88 % compared to 1.38% in the even years, a reduction of 36%. Beacham and Starr 1982 estimated an average survival of .85% for the 1961-74 broods of Fraser wild chum in the odd years compared to 1.53% in the even years, a reduction of 44%.

3.5 Enhanced age composition

Table 3.5.1 shows the age composition of enhanced chum for the 1977 to 1991 brood years. This is based on the finclip scale age or the cwt age of returning marked enhanced chum. Average age composition for catch plus escapement for the 1981-90 broods when most of the enhanced stocks were present was estimated at 11% Age 3, 72% Age 4, and 17% Age 5 for the Non-Fraser stocks and 14% Age 3, 76% Age 4, and 10% Age 5 for Fraser stocks. The slightly earlier age at return for Fraser stocks may be related to rearing of Fraser chum. Age composition in the catch is slightly biased toward older ages.

Table 3.5.2 compares the 1981-90 brood average age composition of marked enhanced stocks with the average age composition of scale aged chum sampled in fishery catches. The data is very similar except for enhanced Fraser stocks that seem to return at a slightly earlier age.

3.6 Summary

Chum enhancement increased dramatically on the Inside South Coast in the early 1980's with the building of three major Japanese-style chum facilities on the Fraser (Chilliwack, Chehalis, and Inch) and a chum hatchery (Puntledge) and spawning channel (Little Qualicum) on mid Vancouver Island. Fed fry production peaked at 33.4 million fed chum fry for the 1982-86 broods. Current fed fry production targets are 15.6 million fed fry. Unfed fry targets have not changed dramatically and are currently at 84.9 million. Actual releases have averaged 70.7 million unfed fry since 1987. Enhanced contribution based on an analysis of mark returns between 1985 and 1997 has averaged 449,000 in the catch and 360,000 in the escapement. This represents 38% of the average catch and 19% of the average escapement for this time period. A substantial number of the enhanced escapement has spawned naturally, thus helping to rebuild natural runs especially in the Fraser. Overall enhanced exploitation rates during this time period have averaged 54% for the Non-Fraser and 27 % for the Fraser. Addition of the enhanced contribution from the U.S., sport, and native catches would probably increase the Fraser exploitation rate to about 36%. These exploitation rates are higher than for wild + enhanced returns because of a concentration of harvest on enhanced mid timing stocks in the mixed stock fisheries as well as a terminal fishery in mid Vancouver Island on only enhanced stocks. Enhanced fry-to-adult survivals have averaged 1.26 % for Non-Fraser and 1.2% for the Fraser (adjusted for U.S. and native catches) which is slightly below the target of 1.5%. Survival of odd-year Fraser enhanced broods are an estimated 36% below even year survival possibly because of competition with Fraser pinks. Age composition from scale aged and cwt aged marks of enhanced stocks for the 1981-90 broods averaged 13.0% Age 3, 72.6% Age 4, 14.1% Age 5, and 0.3% Age 6.

4.0 Status of Inner South Coast Escapement Estimates

Estimating escapement for chum salmon is only one of several requirements for the operation of the Clockwork approach to chum stock assessments. A review of the adequacy of our escapement enumeration system is necessary if the Region is to seriously develop accurate assessments of chum salmon productivity and to use the Clockwork approach to manage Inner South Coast chum salmon.

4.1 Methods

The escapement estimates for each geographic region within the Inner South Coast area were plotted for each year. The target escapement and spawning capacity levels were included to show escapement trends relative to the escapement targets and spawning capacity levels.

The inherent high variability in escapements due to natural annual fluctuations, but in particular, the confounding effects of inconsistent enumeration procedures prevent rigorous statistical testing.

To compare trends between areas of different size and escapement magnitude all escapement data were standardized:

$$Z = \frac{X_I - X}{SD}$$

Where Z = the standard score (i.e. mean =0),

X_I = an original escapement value,

X = the mean of all recorded escapements for each area or aggregate,

SD = standard deviation of all recorded escapements for each area or aggregate

To reduce the effect of changes in observers over time and their unknown level of thoroughness in enumeration spawners and because escapement estimates are obtained by different procedures during some years (i.e. fence counts, mark-recapture visual observations during stream walk and over flights), raw escapement time series data were smoothed using a procedure introduced by Cleveland (1985). Lowess (locally weighted regression) data smoothing was applied to the escapement time series. A "locally weighted" linear regression is used to obtain smoothed values for each value of y, given the values for x. That is, for each x_i, a linear regression is computed in which nearby values are weighted more heavily than values further away. Then the estimated regression coefficients are used to predict a smoothed value for y_i, given x_i.). The procedure is particularly suitable for assessing trends in escapement because it takes into account unequal spacing between years (i.e. missing escapement records) and produces a smoothed function which is not sensitive to outliers. Escapement data typically contains numerous missing values and unexplained outliers. The lowess-smoothed curves were used to clarify the relationships between the escapement estimates and years. Using the standardized and smoothed escapements as a measure of relative abundance, each geographic area or aggregate was examine for years with obvious deflections in escapement from the grand mean (the zero line).

4.2 Escapement Surveys

Most chum escapement estimates are based on visual counts by field staff, exceptions to this being counts at fences or adult tagging programs. Fence counts and tagging programs have been largely limited to large chum salmon stocks that have been enhanced (Big Qualicum and Harrison/Chehalis). Visual estimates are not considered to be accurate estimates of spawning numbers but are treated as indices of trends in escapement (Shardlow et al. 1987). Even then the consistency of these indices among streams and years is uncertain but trends in escapement do reflect trends in catch or test fishing data when these data have been compared. If escapement surveys were consistent in methods and number of streams surveyed each year then assessment studies could express production as the number of chum produced per index spawner, without making assumptions about the accuracy of an escapement estimate.

Average escapement estimates by decade from 1953 to 1997 for systems with at least one chum salmon record and by stock group are presented in Table 4.1. Most of the escapements were estimated by conducting walking surveys, aerial surveys, or float surveys. Although visual surveys produce the least precise and least accurate estimates of absolute escapement, such estimates are the only consistent historical measure of stock status available. Thus escapement trends are considered a relative measure of abundance.

There is concern regarding the inconsistencies in methodologies and the lack of effort directed to escapement enumeration. The methodology for most small (<10,000 spawners) is accomplished by walking the stream and counting the spawners. The methodology for larger systems has varied through time and has included aerial overflights, mark recapture programs, dead pitch surveys, and river floats. In some years there are no field observations or enumeration programs on some individual systems. In some areas there are no observations at all. Figure 4.1 presents a review of the enumeration effort for ISC escapement surveys. Only 27 or 6 % of the 423 chum stocks in the ISC have complete spawning escapement records from 1953 to 1997 and 129 or 36 % of the chum stocks have from 30 to 44 years of escapement estimates. Most chum stocks (209 or 52%) have less than 18 years of observations. From 1953 to 1983 approximately 50% of the 423 chum stocks in the ISC were surveyed each year (Figure 4.2). Effort increased and peaked in 1985 at 65% of the systems being surveyed. Since 1985 the effort has declined to less than 40% of the systems being surveyed each year.

Changes have also occurred in the proportion of escapement contributed by each system to the total escapement (Table 4.3 and Figure 4.3). There has been a steady decrease in the number of stocks required to achieve 85% of the total escapement. Fifty stocks accounted for 85% of the total escapement in the 1950s, 34 in the 1960s, 33 in the 1970s, 28 in the 1980s, and 16 in the 1990s. In the 1990s the Harrison, Stave, and Chilliwack rivers have accounted for 46% of the total escapement to the ISC. These are Fraser River stocks and all have some level of enhancement.

In 1997, a select number of chum streams were independently enumerated using an index section of stream (1000 m), weekly visits and area under the curve analysis methodology. The person responsible for producing the BC16 for the selected streams produced independent escapement estimates using traditional stream enumeration techniques for the SEDS database. On average the estimates obtained by the weekly visual estimates and area under the curve analysis are higher than those reported in the SEDS database (Table 4.4). Increased effort and standardized methodology improved the estimates even though the whole stream was not necessarily surveyed. The 1997 AUC estimates are probably under-estimates because the program terminated for most areas stopped on October 31 prior to the completion of chum spawning in most systems.

4.3 Escapement Targets

Escapement targets or the desired number of spawners for each chum stock have most commonly assumed that production is proportional to spawning area (up to some limit of spawners per unit area). Field staff assesses, usually quantitatively, the spawning habitat used by chum in each stream and extrapolate to a goal based on the habitat used by the number of chum spawners they have observed. Other procedures used to set targets, such as a habitat model assuming a constant number of spawners per unit of habitat, make the same proportionality assumptions.

Quantitative Assessment

The first reported attempt to develop escapement targets for chum salmon runs in the ISC was in 1962. As an interim measure the highest recorded escapements to individual streams during the period 1949 to 1961 were determined and then added together to provide a total escapement target of 2.3 million fish for the entire area. Since that time there have been modifications to the targets for individual sub-areas to the current total of 3.3 million fish (Table 4.3). Most estimates are based on the judgement of people familiar with the spawning area and the rationales for modifications have generally not been well documented.

Stock-Recruitment Analysis

Relatively few target escapement levels have been set based on optimization of adult returns per spawner (stock-recruit theory). Stock-recruit functions are determined over the range of escapements observed and cannot estimate the "true" optimum escapement level unless escapements are allowed to vary from small to very large values periodically. The absence of catch estimates by individual spawning populations or regions (except the Fraser) precludes separate evaluations for individual populations or for most regions within the ISC.

Pearse (1982), on the basis of a stock-recruitment analysis suggested an escapement goal of 1.6 million chum salmon spawners for the ISC. Beacham (1984), in a stock-recruitment analysis of the ISC chum stocks suggested an optimum escapement of 2.9 million chum salmon. He also suggested that optimum escapements may be lower in odd-numbered years than those in even-numbered years, presumably as a result of competitive interactions with pink salmon.

Pearse (1982) suggested a target of 1.0 million chum salmon for the Fraser River but with a wide range from 600 thousand to 3.0 million fish. The large uncertainty is reflected of the relatively narrow range of observed spawners used in the analysis with only one-year when escapements were in excess of 600 thousand fish. A stock-recruitment analysis by Joyce and Cass (1992) indicated that the total wild return of Fraser chum from 1951 to 1991 did not decline with increasing levels of escapement achieved during the same period. Furthermore, the analysis suggested that density-dependent effects on the production of Fraser chum could not be evaluated until the spawning population exceeded 800,000. In 1985, a record high escapement of over 1.1 million chum spawners was recorded. Unfortunately, due to severe winter conditions during 1985-1986 and the resulting unusually high freshwater mortality (independent of density-dependent effects), this production was not carried forward and subsequent returns from this brood-year could not be included in the analysis. More data points at escapement levels of 800,000 spawners or higher are required in order to determine the optimal escapement and harvest levels for Fraser chum. Nevertheless, the data suggest that the optimum overall escapement level for Fraser chum salmon is likely greater than 800,000 spawners, and that the potential exists for rebuilding the Fraser chum stocks to higher levels than at present. Returns from the relatively large escapements in recent years, including the record escapements of nearly 1.5 million fish in 1995 and 1996, should help to establish a realistic escapement goal for the Fraser River in the future.

Habitat Capacity Analysis

There has been limited assessment of habitat capacity for chum salmon spawning in the Inner South Coast. During the early 1960s Palmer (1972) estimated the capacity of several major Fraser River chum-spawning areas based on available spawning area. During the summers of 1969 and 1970, chum producing streams on the east coast of Vancouver Island were surveyed and estimates made for chum spawning capacity (Fraser et al 1974). In 1997, a project was funded under the Pacific Salmon Revitalization Strategy - Habitat Restoration and Enhancement Program to develop and evaluate the use of standard index streams for chum salmon adult enumeration in Areas 11, 12 and 13. The project estimated the capacity of chum spawning for the index streams based on available spawning gravel.

Table 4.5 summarizes available habitat capacity information and target escapements for selective streams within the Inner South Coast. For 44% of the systems in Table 4.5 the habitat capacity estimates provide greater optimum escapement estimates than the target escapements established in 1986. This would suggest that the target estimates are below the optimum spawning capacity for these systems. Conversely, for 50% of the systems the target escapements provide greater optimum escapement estimates than the habitat capacity estimates. In cases where chum habitat spawning capacity estimates have been compared to maximum escapement levels (as indicated by existing target escapements or recent visual estimates) the habitat spawning capacity estimates are considered to be under-estimates of chum spawning capacities (Pearse 1982, Joyce and Cass 1992). This would indicate that habitat spawning capacity estimates indicate the minimum target escapement levels. However, all the estimates are questionable and may not reflect the optimum escapements for any given system. Methods for determining targets escapements are not well documented and are generally based on visual observations or mark recapture estimates that contain inherent biases. The habitat estimates are based on spawning gravel estimates and for the most part these have not been assessed in recent years. Logging activity and urban development have probably resulted in changes to chum spawning habitat in recent years and the estimates should be evaluated. Recent habitat surveys conducted by HRSEP and FsRBC may be a source of new spawning gravel estimates for a majority of streams in the ISC.

4.4 Status of ISC Chum Salmon

Estimates for total, wild and enhanced escapement by system are presented in Table 4.1. Trends in total escapement for the major management regions within the Inner South Coast are presented in Figures 4.4. Summer chum and chum stocks in Seymour and Belize Inlets and those in Areas 19 and 20 of the Southern Vancouver Island group are not included in the Clockwork Management Strategy.

Fall Chum Stocks

There are 421 fall chum stocks with at least one observation recorded in the SEDS database for the ISC. The productivity of chum salmon stocks from these areas is influenced by numerous development activities such as forestry, agriculture, transportation, hydroelectric generation, industry and urban settlement, and ocean survival, all of which have occurred with varying intensity.

Between 1953 and 1997, the estimated total wild escapement for fall chum salmon averaged 1,191,000 with a range from 327,000 in 1995 to 2,627,000 in 1994. The average escapement to the area was 884,000 in the 1950s, declined to 772,000 in the 1960s, and increased to 1,091,000 in the 1970s to 1,807,000 in the 1990s. The escapement target for the ISC is 3,235,100 chum salmon spawners.

Total returns of ISC chum were reduced to low levels during the 1950s and 1960s primarily due to high exploitation rates (Figure 4.4). To address this problem, exploitation rates were drastically reduced in the 1960s, and a "Clockwork" management plan was implemented in 1983. In addition, major enhancement efforts commenced in the early 1980s, and began to show significant returns by 1985. Total returns to the ISC have increased since the mid-1980s (Figure 4.4).

Summer Chum Stocks

Summer chum salmon stocks are passively managed and are incidentally harvested in the Johnstone Strait fishery directed at Fraser River sockeye and pink salmon. The major summer chum stocks occur in the Ahnuhati and Orford rivers. Ahnuhati River summer chum salmon migrate up Knight Inlet from early July, and peak arrival in the river is in late July. The Orford River in Bute Inlet supports both summer and fall runs of chum salmon. The summer run migrates through Johnstone Strait, Sunderland Channel and Chancellor Channel from mid- to late August.

Between 1953 and 1997, the estimated total wild escapement for summer chum salmon averaged 35,400 with a range from 160,000 in 1986 to 1,030 in 1991. Summer chum returns increased from about 13,000 in the 1960s to 50,000 in the 1970s and 1980s. Summer chum stocks have declined since the late 1980s (Figure 4.4). The combined target escapement for the Ahnuhati and Orford summer chum runs is 130,000. A chum spawning channel was constructed in the early 1990s on the Orford River to enhance the summer chum run, but has failed to stabilize or increase run size because of siltation problems. Returns of summer chum have continued to decline.

Seymour/ Belize Inlets

Seymour/ Belize Inlet area includes Statistical Area 11. The chum stocks in this area are passively managed. The three key indicator systems are the Seymour, Waump and Taaltz rivers. The total escapement for the 19 chum stocks in the area averaged less than 22,000 spawners from 1953 to 1997 (Table 4.1). Escapements for these stocks were relatively consistent from the 1950s to the 1970s, averaging 20,000 to 30,000 chum spawners (Figure 4.4). However, during the 1980s and 1990s, chum escapements have decreased to an average of 13,000, which are about 7% of the 165,000 target escapement.

Upper Vancouver Island

The area extends from the Stranby drainage on the northern end of the island to the Cluxewe drainage and encompasses the northern half of Statistical Area 12.

There are 8 passively managed chum populations in the Upper Vancouver Island area. In terms of total production, the most significant stocks are from the Quatse, Keogh, and Cluxewe rivers. During the period from 1953 to 1997, the area's average escapement was 6,200 chum salmon (Table 4.1). Escapement records indicate that chum escapements to the Upper Vancouver Island are steadily declining (Figure 4.4). The average escapement was 23,000 during the 1950s and declined to 9,000 and 1,500 during the 1960s and 70s, receptively. Escapements have declined further in the 1980s and 90s, averaging less than 500 chum or less than 1% of the target escapement. The target escapement for the area is 67,000 chum salmon.

Kingcome Inlet

There are 16 passively managed chum stocks in the Kingcome Inlet area. Escapement records indicate that these stocks have declined from an average of 36,000 in the 1950s to 18,000 in the 1960s, 40,000 in the 1970s, and 10,000 in the 1980s (Table 4.1). Recent escapements (1990-1997) have averaged 1,900, which is less than 0.01% of the target escapement of 200,000 for this area. Escapement estimates have steadily declined since 1980 (Figure 4.4).

Bond/Knight Inlets

There are 24 chum stocks in the Bond/Knight Inlets. Average escapements have declined from 131,000 in the 1950s to 47,000 in the 1980s. In past years, Viner Sound Creek has accounted for 65% of the total chum escapement for the area and has averaged escapement in the order of

25,000 to 50,000 spawners during 1953-1989. The Viner Sound Creek supports both an early and a late run of fall chum. The early run, which is the main chum stock, arrives in the river from late September to mid October. The later run arrives near the end of October. During the 1990s, average escapements have dropped to 10,000 for the area and 4,600 for Viner Sound chum salmon. The target escapement for the area is 346,000 chum salmon. Escapement estimates show a marked decline throughout the time series (Figure 4.4).

Johnstone Strait

The Johnstone Strait area encompasses the southern half of Statistical Area 12 and most of Area 13 on Vancouver Island. It includes streams between Port McNeill and Campbell River from the Nimpkish River in the north to Mohun Creek in the south.

In the Johnstone Strait area there is one actively managed and 13 passively managed chum stocks. The Nimpkish River is the actively managed stock and has contributed more than 75% of the chum escapement to the area. The average escapement to the area was 61,000 in the 1950s, declined to 18,000 in the 1970s, increased to 48,000 in the 1980s and has increased to 72,000 in the 1990s (Table 4.1). The target escapement is 190,000 spawners for the Johnstone Strait area.

Loughborough/Bute Inlets

This area includes the mainland and island portions of Statistical Area 13 and Ramsay Arm and Port Neville in Area 12.

There are three actively managed (Orford, Homathko, and Southgate) and 32 passively managed chum stocks in the Loughborough/Bute area. The Orford River supports both summer and fall runs of chum salmon. The migration timing of the other chum stocks from the Loughborough/Bute area is similar to that of other fall runs on the south coast, September through November. The total chum escapement for fall runs was 49,000 in the 1950s; 35,000 in the 1960s; 97,000 in the 1970s; and 150,000 in the 1980s. Escapement estimates have generally declined since the mid-1980s (Figure 4.4). The target escapement for the area is 437,000 chum.

Mid Vancouver Island

The area from Campbell River to Nanoose Bay is considered the Mid Vancouver Island area. It includes the lower portion of Statistical Area 13 and all of Area 14.

There are 33 chum stocks in the Mid Vancouver Island area. The three actively managed stocks, Big and Little Qualicum and the Puntledge rivers, accounted for about 90% of the total escapement during the 1980s. Although these three systems are currently enhanced, they have historically accounted for the majority of chum escapement to the area. Escapements to these systems represent about 70%, 85%, and 90% of total escapement during the 1950s, 1960s and 1970s, respectively. Total escapements to the area have increased from 130,000 chum in the

1950s to 150,000 in the 1990s. The total wild target escapement for the area is 239,500 chum. The time series trend for MVI stocks has increased since 1965 (Figure 4.4).

Toba Inlet

The Toba Inlet area includes all of Statistical Area 15 and Ramsey Arm in Area 13.

There are 15 systems in Toba Inlet that support chum salmon. Only the Okeover and Toba River stocks are actively managed. In the 1980s these stocks accounted for 60% of the total chum escapement to the area. Total escapement averaged 52,000 in the 1950s and declined to 21,000 in the 1960s, 16,000 in the 1970s, 10,000 in the 1980s, and 740 in the early 1990s. Escapement enumeration effort has also decline in Toba Inlet with less than 4 systems surveyed each year since 1989. The target escapement is 180,000 chum salmon. Escapement estimates show a marked decline throughout the time series (Figure 4.4).

Jervis Inlet

The Jervis Inlet area includes all of Statistical Area 16.

There are 36 streams in Jervis Inlet that support chum salmon populations. The five actively managed stocks (Deserted, Pender Harbour, Saltery Bay, Sliammon, and Tzoonie) account for more than 70% of the total escapement. Chum returns have ranged from 56,000 to 96,000 in previous decades to an average of 108,000 during the 1990s. The target escapement is 140,100 chum salmon.

Lower Vancouver Island

The Lower Vancouver Island area is located between Nanoose Bay and Crofton and includes Statistical Area 17.

There are 18 streams in the Lower Vancouver Island area that support chum salmon populations. Of the Lower Vancouver Island chum stocks, only the Nanaimo is actively managed. This stock accounted for 75% of the total escapement to the area from 1953 to 1997. Average escapements to the area were 68,000 in the 1950s, declined to 32,000 in the 1960s, increased to 54,000 in the 1970s and 65,000 in the 1980s and 1990s. The target escapement is 134,000 chum salmon.

Southern Vancouver Island

Southern Vancouver Island refers to the area from Crofton and east of Port Renfrew and includes Statistical Areas 18, 19, and 20.

There are 9 chum stocks in the Southern Vancouver Island area. The four major stocks are the Chemainus, Cowichan, Koksilah, and Goldstream. Escapements for these stocks have been relatively consistent from the 1953 to 1997, averaging 114,000 chum spawners. During the 1980s and 1990s, chum escapements increased to an average of 166,000 and 160,000, respectively, which are about 75% of the 214,000 target escapement.

Howe Sound/Sunshine Coast

There are 56 streams in the Howe Sound/Sunshine Coast area that support chum salmon. However, the Squamish and the Cheakamus are considered the major producers and account for 80% of the total escapement between 1953 and 1997. Total escapement averaged 56,000 chum from 1950s, increased to 131,000 in the 1970s and to 154,000 in the 1980s. Total escapement has declined to 96,000 in the 1990s. The target escapement is 357,500 chum for Howe Sound/Sunshine Coast.

Burrard Inlet

There are 13 streams in the Burrard Inlet area that support chum salmon. The Indian River is the major stock and accounts for over 90% of the total escapement to the area. Total escapements have averaged 21,000 from 1953 to 1997 and show a steady increase over time (Figure 4.4). The target escapement is 33,000 chum salmon for Burrard Inlet

Fraser River

The Fraser River area includes all of Statistical Area 29, except for Boundary Bay.

Fraser River chum salmon are managed to total abundance rather than as individual stocks. Chum salmon spawning is largely confined to that portion of the Fraser River below Hope. There are 121 streams in the Fraser River that support chum salmon, although 10 stocks support 90% of the total spawning escapement. The largest producers are the Harrison, Chilliwack, Chehalis and Stave rivers. Spawning also takes place in the mainstem of the Fraser River between Chilliwack and Hope but there are no reliable estimates for the contribution of mainstem spawners because of the turbid nature of the Fraser River. Total escapements to the Fraser averaged 99,000 in the 1950s, increased to 250,000 in the 1960s, and to 339,000 in the 1970s. The number of chum returns increased to 518,000 in the 1980s and to 1,003,000 in the 1990s. The Harrison, Chilliwack and Stave River systems account for 56%, 18%, and 9% of the total escapement, respectively. The current target for chum escapement to the Fraser River is 700,000.

Boundary Bay

The Boundary Bay area includes the streams that flow in to Boundary Bay, which is part of Statistical Area 29.

In the Boundary Bay area there are 4 passively managed chum stocks. The Campbell River is the largest stock and has contributed more than 80 % of the chum escapement to the area. The average escapement from 1953 to 1997 has been 334 chum. The target escapement for the Boundary Bay area is 5,000 chum salmon.

4.5 Summary

Chum escapements to all systems have shown marked fluctuations since 1953. The trend for all fall chum stocks combined is an increase in escapement levels while the trend for summer chum stocks is a decline in escapement levels after 1980.

There is variability in the escapement trends among geographic regions within the ISC. A rather marked decline in escapement trends for fall chum salmon has occurred in Upper Vancouver Island, Kingcome Inlet, Bond and Knight Inlets, and Toba Inlet. Escapements to Seymour and Belize Inlets, Jervis Inlet, Lower Vancouver Island, and Boundary Bay are currently about equal to the long-term average escapements. Escapements to Johnstone Strait, Loughborough and Bute Inlets, Mid Vancouver Island, Jervis Inlet, Lower Vancouver Island, Southern Vancouver Island, Howe Sound and Sunshine Coast, Burrard Inlet, Fraser River, and Boundary Bay show moderate growth. However, most stock groups except for Burrard Inlet and the Fraser River are well below the established target escapement levels.

Escapement levels for summer chums have declined since the early 1980. Summer chums are passively managed and enhancement efforts have not been successful. Changes in the harvest rates for Johnstone Strait sockeye and pink fisheries may be required to rebuild summer chum stocks. Alternately, the non-retention summer chum along with coho during selective fishing for sockeye and pink salmon in Johnstone Strait could increase the number of the summer chum returns.

Fall chum salmon stocks in Upper Vancouver Island, Kingcome Inlet, Bond and Knight Inlets, and Toba Inlet are not responding to the Clockwork management plan, which has reduced harvest rates on chum salmon. Natural rebuilding of these stocks may occur if harvest rates are further reduced. However, the decline of these stocks may result from other factors. The systems in these areas are subject to wide fluctuations in flow. They are characterized by summer freshet conditions resulting from snow and ice melt in the headwaters at high elevations and some of the rivers are also subject to winter floods that result from rain and snowmelt at lower elevations. Many of the streams are turbid. Forestry has been the only development activity in most of these drainages. Extensive clearcutting has exaggerated the natural fluctuations in river flow, changed temperature regimes, and contributed to the instability in these systems (DFO 1988). Chum salmon limit their freshwater life to spawning and incubation and spend their growing period at sea which is far more productive than their natal stream but there is a greater potential for predation in the ocean. Chum salmon typically spawn in the lower sections of rivers where impacts of upstream activities accumulate (Scrivener1991). Chum salmon production is at risk from the impacts of major habitat disturbances such as elevated sediment loads and temperature, unstable river flows and turbidity, which is due in part to logging activities (Hartman et al. 1996). Erosion of stream banks and transport of fine sediment causes a decline in the quality and stability of chum spawning gravel and a decline in egg to fry survival and a reduction in fry size (Scrivener and Brownlee 1989). Increased incubation temperatures accelerate embryonic development and emergence of chum fry (Holtby 1988). Fewer smaller fry and early emigration to the ocean cause fewer adults to return after logging (Scrivener 1991). Chum salmon survival at sea is dependent on ocean conditions that have nothing to do with logging. Chum salmon returns to unlogged streams on the West Coast of Vancouver Island declined with poor ocean conditions and increased when conditions improved, but populations within logged areas did not recover when ocean conditions improved (Scrivener 1991). Although regeneration of forest cover and improved logging practices will improve the hydrology of some systems, chum production is expected to remain low and variable in areas affected by logging. However, when favourable ocean conditions produce increased chum returns then fishing effort should be reduced to allow escapement levels to increase in areas affected by past logging. If spawning habitat has improved then higher escapement levels should increase chum production.

Another factor that contributes to the uncertainty about escapement trends is the effort presently used to obtain the escapement estimates. There is no question that different enumeration methods and levels of effort result in differences in data quality. This is a significant truism given the tendency of each enumerator to apply his own preferred method and level of effort on the streams for which he is responsible. It is doubly important in view of the steady reduction in manpower resources available for enumeration activities over the past several decades. Therefore, streams in most areas can be divided into two very broad categories. In the first category are a few systems, which receive a maximum amount of effort because they are major chum producers or they are utilized as indictors for in-season management decisions. The second and much larger category consists of streams, which are visited infrequently, often to determine little more than presence or absence of spawners; they are typically smaller or less-accessible streams. The reliability of spawning escapement data obviously is much higher in the first category than it is in the second. Areas such as Upper Vancouver Island, Kingcome Inlet, Bond and Knight Inlets, and Toba Inlet fall into the second category. Declining escapement surveys may partially explain the declining trend in chum spawning escapements in these areas. For example no reported escapement enumeration efforts in Toba Inlet area between 1994 and 1996 and limited escapement surveys since 1989. The reported escapements for some chum systems may be artificially high because of the practice of recording escapement numbers for systems that are highly turbid or glacial. Escapement estimates during the 1980s and 1990s have remained relatively high in Loughborough/Bute Inlets compared to the other mainland inlet areas. One factor that has contributed to these high averages is the continued practice of assigning high escapement estimates to large glacial systems like the Homathko, Southgate and Orford rivers. It is impossible to assign a reasonable escapement estimate to a large glacial river from a visual survey. Alternative assessment methods are required to produce meaningful escapement estimates for large glacial systems. In the Fraser River, the escapement estimates for the major chum salmon stocks are derived from mark recapture estimates. Estimates have gone from visual to mark recapture estimates without the benefit of conducting both methods for several years prior to adopting the new method. Mark recapture estimates of salmon are almost always over-estimates of the true population size (Simpson 1984).

To address concerns over the quality of escapement enumeration surveys, changes have been made to ensure standardization of data collection. An escapement enumeration plan is developed each year for chum stocks within the Inner South Coast. Rather than trying to assess all chum salmon streams, a representative group of stocks are selected. Chum salmon spawning streams are assessed for inclusion in the escapement plan using the following criteria: 1) importance of past chum production to overall chum production within each area, 2) importance to in-season management and possibility of terminal commercial fisheries; 3) accessibility and easy of enumeration; 4) hazards; 5) consistency of past enumeration data; 6) presence of ongoing enumeration programs; 7) presence of local community groups interested in participating in stream enumeration. Using the above criteria would result in surveying approximately 140 of the 423 stocks presented in ISC. This not to say that the remaining stocks would not be surveyed but that the effort directed to the remaining stocks would be less and may only include presence or absence information.

The goal of the escapement plan is to provide true and relative abundance estimates with a high degree of resolution for a select number of the chum stocks within the ISC. The abundance estimates are based on the systematic and consistent application of a single standard assessment method for each spawning population. The assessment methods include fences, mark-recapture and area under the curve to provide estimates of abundance. The stocks are to be assessed throughout the season with a minimum of 5 visits. Factors such as weather, water levels and observation conditions (water clarity) affect the number of observations each year. The use of consistent methods and recording what is actually seen without expansion prior to the application of standard methods should improve the reliability of escapement estimates for ISC chum salmon.

5.0 Stock Recruitment Analysis of Fraser River Chum Salmon and Comparison to aggregate Clockwork Wild Chum stocks.

5.1 Methods

Stock Assessment analysis usually consists of examining the empirical relationship between the spawning stock size and the subsequent recruitment of the year class (es) produced by that stock. Analysis of this relationship is essential in understanding the dynamics of the stock of interest and is necessary to answer questions of abundance and allocation.

The purpose of this analysis is to update earlier stock/recruit analysis of chum salmon by Beacham and Starr (1982), Beacham (1984) and Joyce and Cass (1992) and to recalculate parameters of productivity of two major groupings of chums; namely wild Fraser River origin chums, and wild clockwork chums. (Catch estimates for individual spawning populations preclude separate evaluations for individual populations.) These parameters will help us to assess the establishment of an appropriate escapement target and optimal harvest strategy. Joyce and Cass (1992) properly point out the need for a probing strategy at high escapements to allow a testing of density dependent effects. They examined brood years 1959 –1986, which did not contain many high escapements. Increased escapements since are incorporated into this analysis.

The Ricker model of the form:

$$R=Se^{a(1-S/b)} + e^{(w)} \qquad (1)$$

was fitted over the range of spawner-recruit data (1959-1992 brood years for wild Fraser River data and 1955 to 1993 brood years for the clockwork wild chum data). From equation 1, the returns R in a year t are a function of the spawning escapement S in the previous year(s). Parameter a is the productivity parameter (e^a = return spawners in the absence of density dependence). Parameter b is the density dependent parameter. The parameter w is the residual errors, which are log-normally distributed. This is the preferred form of the Ricker model when applied to salmon populations (Hilborn and Walters 1992, Quinn and Deriso 1999, Brink 1998). For fitting, equation 1 is transformed into

$$Ln(R/S) = a - (a/b)S + w \qquad (2)$$

which is a linear model of the form

$$Y = b_0 + b_1 X + w$$

where $Y = Ln(R/S)$ is the dependent variable, $b_0 = a$ is the intercept, $b_1 = -a/b$ is the intercept, and w is the residual. Estimates of parameters a and b are estimated from the subsequent regression. Hilborn (1985a) has shown that the expected value of e^w is not equal to zero when w is normally distributed with a mean of zero but equal to $e^{\sigma 2/2}$, and therefore, the average stock-recruitment curve will be a Ricker curve with the parameters a' and b' which can be defined as

$$\begin{aligned} a' &= a + \sigma^2/2 \\ b' &= (a'/a)b \end{aligned} \qquad (3)$$

Hilborn (1985b) has also shown that the optimal stock size for MSY can be approximated by

$$Smsy = b'(0.5 - 0.07a') \qquad (4)$$

And the corresponding approximation of optimal harvest rate Umsy is

$$Umsy = 0.5a' - 0.07a'^2 \qquad (5)$$

Two other important parameters are the maximum stock size Smax and the maximum recruitment size Rmax. These are calculated as

$$\begin{aligned} Smax &= b'/a' \\ Rmax &= (b' e^{a'-1})/a' \end{aligned} \qquad (6)$$

The Harvestable surplus can be then calculated by first calculating

$$MSYSmsy = Smsy * e^{a'[1-(Smsy/b')]} \qquad (7)$$

And finally:

$$\text{Harvestable Surplus} = \text{MSYSmsy} - \text{Ssmy} \qquad (8)$$

Chum Clockwork escapements records are up to date but the data from 1997 to the present are to be considered preliminary and are subject to change. Fraser River catches are complete to 1997. The analysis for Fraser stocks (Harrison and surrounding sloughs, Chehalis, Vedder/Chilliwack, and Stave/Nicomen/Norrish) incorporates data from 1959 to 1992 brood years. We cannot use the 1993 brood data because we need complete 1998 catch and escapement of Fraser origin chums to complete the 1993 cohort data. Clockwork chum analysis covers the 1955 to 1992 brood years. These data are shown in Tables 5.1 and 5.2 respectively. The analysis deals with wild origin fish exclusively.

1) Total wild returns (recruitment) were calculated by the following production model.

$$\text{Total Wild Return}_t = \text{Wild Return}_{age3} + \text{Wild Return}_{age4} + \text{Wild Return}_{age35}$$

Where

$$\text{Wild Return by age} = \text{Net Wild Return} * \text{proportion of catch at age}$$

Where age = 3,4,5.

$$\text{Net Wild Return} = \text{Total Wild Catch} + \text{Net Wild Escapement}$$

Where

$$\text{Net Wild Catch} = \text{Total Catch} - \text{Enhanced Catch} \quad \text{and}$$

$$\text{Net Wild Escapement} = \text{Gross Escapement} - \text{Enhanced Escapement}$$

2) Returns/ Spawners were calculated by

Net Wild Returns/ Net Spawners

Where

Net Spawners = All chum spawning in natural or semi-enhanced areas.

This simple model has been used by Joyce and Cass (1992) and was reproduced for comparison purposes.

All model results and raw data were transferred into Stata (release 5) for analysis. Stata is a statistical analysis, modelling, and graphing program. It has been certified accurate for use in medical research.

5.3 Results

Fraser River Chums

The recruits vs spawners for the Fraser River chum stocks are plotted in Figure 5.1. An examination of the plot indicates several features commonly seen in stock recruitment relationships: (1) There is a trend for larger spawning stock to produce more recruits, (2) there is evidence of decreasing production at larger stock size, (3) the data is highly scattered, and (4) there is increased variability at higher stock sizes.

The Recruits per Spawner data are plotted in Figure 5.2 and show two typical features; high variability at low stock size and there appears to be a trend for decreased survival or density effects at higher stock sizes.

Ricker Estimates for Fraser River Chum

The results of fitting by regression of log R/S vs S with the model described by equations 2 are presented below.

```
  Source |       SS       df       MS              Number of obs =    34
---------+------------------------------              F( 1,32)    =  3.99
   Model |  .977054203     1   .977054203          Prob > F     = 0.0542
Residual |  7.82820100    32   .245367672          R-squared    = 0.111
---------+------------------------------           Adj R-squared = 0.0832
   Total |  8.96769794    33   .271748422          Root MSE     =  .4946

------------------------------------------------------------------------------
 Ln(R/S) |     Coef.     Std. Err.       t     P>|t|      [95% Conf. Interval]
---------+--------------------------------------------------------------------
       b |  -6.16e-07    3.09e-07     -1.999   0.054     -1.24e-06   1.18e-08
       a |   .992864    .1549752      6.407   0.000      .6771899   1.308538
------------------------------------------------------------------------------
```

The fit of the model to the data (Figure 5.3) was statistically significant ($p<.05$) but this is barely significant. The density dependent parameter b of the Ricker Model is also barely significant ($p<0.054$) indicating that the slope is marginally different from zero. This allows us to tentatively reject the hypothesis that the returns are simply a linear function of spawning escapement and indicate that some degree of density dependent effects are demonstrated. However, any conclusion must be tempered with the poor correlation as indicated by the Coefficient of Determination (R-squared) = 0.111. This indicates that only 11.1 % of the variation seen in the Ln(R/S) can be explained by the variation in Spawners.

The regression estimates are:

B_0 = a = .992864
B_1 = b = -6.16e-07

From equation 3 the Ricker a' value is 1.070352 and the Ricker b' value is 1,737,787

The Stock Parameters as defined in equations 4, 5, and 6 are

Slope at Origin	Smax	Rmax	Smsy	MsySmsy	Umsy
2.916405	1,623,566	1,741,900	738,690	1,366,831	.46

The indicated optimal harvest rate is 45.4% and the Harvestalbe surplus is 628,140. Summary of the stock parameters and comparison with other studies are found in Table 5.3.

The predicted linear values $Y = B_0 + B_1 X$ where Y is Ln(R/S) and X is S are also plotted in Figure 5.3.

Residuals for Fraser River Chums

The residuals of the model fit are plotted in Figure 5.4. The indicated pattern of the residuals does not indicate any abnormal anomalies. However, two post-fit tests were calculated to test whether there are any problems with the model fit. The results of the Ramsey RESET test using powers of the fitted values of Ln(R/S) for the

Ho: model has no omitted variables

are

```
F (3, 31)     =     8.85
Prob > F      =     0.0002
```

indicating that the null hypothesis should be rejected. This suggests that the simple linear model does not give the best fit and that a more complicated relation between Ln(R/S) and S may be necessary to give a better fit of the observed data.

The Cook-Weisberg test for heteroscedasticity using fitted values of Ln(R/S) for the

Ho: Constant variance

are

```
chi2 (1)       =    0.23
Prob > chi2    =    0.6331
```

indicated that the null hypothesis is supported. This indicates that variance is constant through the fit supporting the conclusion of no anomalies in the residuals. A summary of the residuals is:

```
Variable |  Obs    Mean      Std. Dev.    Min        Max
---------+-----------------------------------------------------
  resids |   34   1.37e-09  .4870446  -1.110177  1.002613
```

Fitting the Ricker Curve for Fraser River Chums

The fit of the Ricker model indicated by equation 1 with the parameters calculated above is plotted in Figure 5.5. Joyce and Cass (1992) speculated that unless there were significant escapements (> 800,000), it would be unlikely that density dependent effects could be tested. The 4 data points since their study that are > 800,000 spawners are important in that the shape of the curve shows that density dependent effects may be operative. Since 1986, there has been a general increase in escapement to the Fraser River. Figure 5.6 shows a clear increasing trend in escapement which has allowed us to calculate a more representative stock-recruitment relationship. We did not fit a curve to this data as the increasing escapement is self-evident. The trend toward increasing escapement continued into 1998 with an estimated at 3.3 million escapement for the Fraser River. This level of escapement is above the established clockwork target.

Along with increased escapement, Figure 5.7 indicates that an increasing trend for wild production up to 1992 has been operative. The results of fitting a linear model of the form $Y = B_0 + B_1 X$ to the production data vs year gives the following results:

```
  Source |      SS        df      MS            Number of obs   =     34
---------+------------------------------         F(  1,    32)  =   7.61
   Model | 1.9026e+12     1  1.9026e+12          Prob > F       = 0.0095
Residual | 7.9998e+12    32  2.4999e+11          R-squared      = 0.1921
---------+------------------------------         Adj R-squared  = 0.1669
   Total | 9.9024e+12    33  3.0007e+11          Root MSE       = 5.0e+05

------------------------------------------------------------------------
totalret |     Coef.    Std. Err.       t     P>|t|    [95% Conf. Interval]
---------+--------------------------------------------------------------
      B1 |  24112.24    8740.246     2.759   0.010     6308.945   41915.54
      B0 | -4.67e+07    1.73e+07    -2.707   0.011    -8.19e+07  -1.16e+07
```

The fit of the model to the data (Figure 5.7) is significant ($p < 0.01$) and the slope of the line is significant as well ($p < 0.01$). However, the Coefficient of Determination (R-squared) = 0.1921 indicating that only 19% of the variation in the production can be explained by the variation in the independent variable. An examination of the residuals did not reveal any anomalies and the post-fit tests did however indicate a problem with omitted variables. The Ramsey RESET test using powers of the fitted values of the production with

```
    Ho:  model has no omitted variables
```

are

```
         F (3, 35)   =      6.46
         Prob > F    =      0.0013
```

leading to a rejection of the null hypothesis. This would indicate that a more complex model would be a better fit to the data. The Cook-Weisberg test for heteroscedasticity using fitted values of the production with

Ho: Constant variance

are

```
chi2 (1)        =     0.06
Prob > chi2     =     0.8040
```

Indicating an acceptance of the null hypothesis that variance in the residuals is constant over the data.

A leverage plot of the data is shown in Figure 5.8a. The data points above the horizontal line have higher than average leverage and the data points to the right of the vertical line have higher than average residuals. The pattern shown indicates that there are slightly more points with higher than average leverage than with larger than average residuals. This diagnostic indicates that there may be some cyclic behaviour in the residuals. As the Ramsey reset test indicated that the model had omitted variables; to discern the functional form of the model, a component plus residual plot was done and is presented in Figure 5.8b. The graph indicates that although an increasing linear trend is present, the proscribed functional form of the model may bears out the cyclic nature of the residuals. This may indicate a cyclic behaviour component or at the very least, non-linearity in Fraser River chum production. 80 and 95% bootstrap confidence limits for the Ricker parameters are presented in Appendix 2.

Clockwork Chums

The recruits vs spawners for the Clockwork (all wild) chum stocks are plotted in Figure 5.9. An examination of the plot indicates that like the Fraser River data, there are several features commonly seen in stock recruitment relationships: (1) There is a trend for larger spawning stock to produce more recruits, (2) there is evidence of decreasing production at larger stock size, (3) the data is highly scattered, and (4) there is increased variability at higher stock sizes.

The Recruits per Spawner data are plotted in Figure 5.10 and again show two typical features; high variability at low stock size and there appears to be a trend for decreased survival or density effects at higher stock sizes.

Ricker Estimates for Clockwork Chum

The results of fitting by regression of log R/S vs S with the model described by equation 2 are presented below.

```
------------------------------------------------------------------------------------------
  Source |      SS        df        MS              Number of obs =    39
 ---------+------------------------------------          F( 1,32)      = 2.92
  Model | 1.03310099     1      1. 03310099           Prob > F      = 0.0957
```

```
Residual | 13.0804057   37       . 353524479          R-squared     = 0.0732
---------+-------------------------------------------  Adj R-squared = 0.0482
   Total | 14.1135067   38       .371408072            Root MSE      = .59458

 --------------------------------------------------------------------------------
 Ln(R/S) |  Coef.       Std. Err.     t      P>|t|    [95% Conf. Interval]
 ---------+----------------------------------------------------------------------
    b    |  -3.82e-07  2.23e-07   -1.709  0.096     -8.34e-07   7.07e-08
    a    |  .8876809   .2540885    3.494  0.001     .3728488    1.402513
```

The fit of the model to the data (Figure 5.11) was not statistically significant (p>.09) but this is barely non -significant. The density dependent parameter b of the Ricker Model is also barely non-significant (p>0.096) indicating that the slope is not different from zero. This does not allows us to tentatively reject the hypothesis that the returns are simply a linear function of spawning escapement and indicate that a small degree of density dependent effects are demonstrated. However, any conclusion must also be tempered with the poor correlation as indicated by the Coefficient of Determination (R-squared) = 0.0732. This indicates that only 7.3% of the variation seen in the Ln(R/S) can be explained by the variation in Spawners.

The regression estimates are:

B_0 = a = .8876809
B_1 = b = -3.82e-07

From equation 3 the Ricker a' value is 1.014725 and the Ricker b' value is 2,659,544.

The Stock Parameters as defined in equations 4, 5, and 6 are

Slope at Origin	Smax	Rmax	Smsy	MsySmsy	Umsy
2.758605	2,620,950	2,659,830	1,140,863	2,036,482	.44

The indicated optimal harvest rate is 43.5% and the Harvestable surplus is 895,619.

The predicted linear values $Y = B_0 + B_1 X$ where Y is Ln(R/S) and X is S is also plotted in Figure 5.11.

Residuals for Clockwork Chums

The residuals of the model fit are plotted in Figure 5.12. The indicated pattern of the residuals does not indicate any abnormal anomalies. However, two post-fit tests were calculated to test whether there are any problems with the model fit. The results of the Ramsey RESET test using powers of the fitted values of Ln(R/S) for the

Ho: model has no omitted variables

are

F (3, 34) = 0.98
Prob > F = 0.4144

indicating that the null hypothesis should not be rejected. This suggests that the simple linear model gives the best fit and that a more complicated relation between Ln(R/S) and S may not be necessary.

The Cook-Weisberg test for heteroscedasticity using fitted values of Ln(R/S) for the

Ho: Constant variance

Are

chi2 (1) = 0.19
Prob > chi2 = 0.6022

Indicated that the null hypothesis is supported. This indicates that variance is constant through the fit supporting the conclusion of no anomalies in the residuals. A summary of the residuals is:

```
Variable |   Obs      Mean      Std. Dev.      Min         Max
---------+----------------------------------------------------------
  resids |    39   3.58e-10   .5867037   -1.667917   .9546214
```

Fitting the Ricker Curve for Clockwork Chums

The fit of the Ricker model indicated by equation 1 with the parameters calculated above is plotted in Figure 5.13. The data and fitted line indicate that density dependent effects are operative.

As with the Fraser River chum, the escapement of clockwork chums has increased since 1980. This increasing trend in escapement can be clearly seen in Figure 5.14.

Along with increased escapement, Figure 5.15 indicates that an increasing trend for wild production up to 1993 has been operative. The results of fitting a linear model of the form $Y = B_0 + B_1 X$ to the production data vs year gives the following results:

```
Source   |     SS         df     MS            Number of obs  =    39
---------+--------------------------              F( 1,   37)  =   4.38
  Model  | 4.6494e+12     1  4.6494e+12          Prob > F      =  0.0432
Residual | 3.9245e+13    37  1.0607e+12          R-squared     =  0.1059
---------+--------------------------              Adj R-squared =  0.0818
  Total  | 4.3894e+13    38  1.1551e+12          Root MSE      =  1.0e+06

--------------------------------------------------------------------------------
```

```
totalret |   Coef.     Std. Err.    t       P>|t|     [95% Conf. Interval]
---------+-----------------------------------------------------------------
  B0     |  30678.42   14653      2.094   0.043     988.6126   60368.22
  B1     | -5.87e+07   2.89e+07  -2.028   0.050    -1.17e+08  -60264.56
---------------------------------------------------------------------------
```

The fit of the model to the data (Figure 5.15) is significant ($p < 0.04$) and the slope of the line is significant as well ($p < 0.043$). However, the Coefficient of Determination (R-squared) = 0.1059 indicating that only 10% of the variation in the production can be explained by the variation in the independent variable. An examination of the residuals did not reveal any anomalies and the post fit tests did not indicate a problem with omitted variables. The Ramsey RESET test using powers of the fitted values of the production with

Ho: model has no omitted variables

are

F (3, 34) = 0.32
Prob > F = 0.8117

leading to an acceptance of the null hypothesis. This would indicate that a more complex model would not be a better fit to the data. The Cook-Weisberg test for heteroscedasticity using fitted values of the production with

Ho: Constant variance

are

hi2 (1) = 0.17
Prob > chi2 = 0.6762

indicating an acceptance of the null hypothesis that variance in the residuals is constant over the data.

A leverage plot of the data is shown in Figure 5.16a and component plus residual plot was done and is presented in Figure 5.16b. Unlike the Fraser River data, the clockwork data indicate that the linear model is the appropriate functional form. The 80 and 95% bootstrap confidence limits for the Ricker parameters are presented in Appendix 2.

5.4 Summary

Returns of Fraser River and clockwork chum salmon have fluctuated widely, however, recent increased escapement levels and increased production have allowed us to detect density dependent effects that were not apparent in earlier studies. The trend in increased escapement and production would indicate that the Clockwork strategy has progressed as planned, with the target level escapement of 2.5 million exceeded in 1998 (preliminary estimate). Comparisons of the major stock parameters from earlier studies are shown in Table 5.3.

The current data results for Fraser River chum closely follow results from Joyce and Cass (1992). The present study estimates Smsy of 739,00 (479,000 – 2,482,000 80%CL) versus 485,000 estimated by Joyce and Cass (1992). Optimal harvest rates for the two studies are in agreement at 45-46%.

There is though, a large discrepancy between the results found here for wild Clockwork chum and those found by Beacham (1984). The additional years of data in the present analysis indicate a vastly different relationship and the possibility of density dependent effects that were not observed in the earlier data set. Consequently, the estimate for Smsy is estimated to be only 1,140,000 (812,000 – 4,212,000 80%CL) in this analysis versus 2,887,000 estimated by Beacham (1984). It should be noted though, that our relationship is heavily influenced by a single data point 1985. If this point is removed, the estimate of Smsy increases from 1,1,40,000 to 2,430,000. Given the large uncertainty in the b parameter and the marginal significance of the stock-recruit relationship we urge caution in the application of the stock-recruit model to estimate Smsy. We also note the large disparity between the stock-recruit estimate of Smsy of 1,140,000 for all wild Clockwork stocks and estimate of spawning habitat discussed in section 4.0.

Estimates of exploitation reveal a slight decrease from the average of 44% in the 1950s to 38% in the 1980s to 27% in the 1990js (Figure 5.17). The average exploitation rate for the period covering Clockwork management (1983-1993) was 37%. This is slightly less than the Umsy estimate of 45% (39% - 53%; Umsy 80% CL).

6.0 Mission Downstream Data

6.1 Methods

Joyce and Cass (1992) used the relationship between standardized fry CPUE measured at Mission and subsequent adult returns for the 1964 to 1986 brood years to assess potential density dependent marine survival effects. The fry index measured at Mission does not include stocks below Mission however, it is assumed to be representative of fry abundance (Joyce and Cass 1992). Joyce and Cass (1992) found no evidence of density dependent marine effects on fry survival.

6.2 Results

The results of the linear fit of standardized fry CPUE vs total adult returns for that brood year are as follows:

```
Source  |    SS        df    MS          Number of obs =    28
--------+---------------------------       F( 1,   26) =  19.38
```

```
     Model  | 3.1469e+12   1  3.1469e+12          Prob > F      = 0.0002
  Residual  | 4.2217e+12  26  1.6237e+11          R-squared     = 0.4271
 -----------+-----------------------------------  Adj R-squared = 0.4050
     Total  | 7.3686e+12  27  2.7291e+11          Root MSE      = 4.0e+05

-------------------------------------------------------------------------------
 totalret  |    Coef.      Std. Err.      t      P>|t|     [95% Conf. Interval]
-----------+-------------------------------------------------------------------
 totalcpu  |  495.8424    112.6319     4.402   0.000     264.3243    727.3605
    _cons  |  222872      195011       1.143   0.264    -177978.9    623722.9
-------------------------------------------------------------------------------
```

Fry CPUE is linearly correlated with subsequent adult brood year returns (p<0.0002) for the 1964 to 1992 brood years. Within the range of these observations there is no evidence for density dependent marine effects on survival. These findings are consistent with the conclusions reached by Joyce and Cass. The graph of standardized fry CPUE vs total adult returns with the predicted values are plotted in Figure 6.

To assess whether the linear relationship between standardized fry CPUE vs total adult returns can be used for predictive purposes, a heuristic retrospective analysis was done to assess the predictive relationship between measured fry CPUE and subsequent returns. For the brood years 1986 to 1992, regression data was calculated for data up to and including that brood year. The subsequent fry CPUE was then used to estimate the expected total return of adults from that brood year. The prediction was then compared to the total return for that brood year and a percent difference was calculated. The algorithm is heuristic albeit in a simplistic sense, as each year incorporates new information into the regression estimates.

The results show that for the 1986 to 1992 brood years, there is a wide range of percent difference (error) between years (Table 6.1).

6.3 Summary

For most of the years, the prediction overestimated the Total Returns. From these results, it would appear that the use of the Standard Fry CPUE is not a particularly useful tool for prediction of Total Returns in this present form. This is not entirely unexpected, as the fitted model is a linear with low correlation between the variables (mean Coefficient of Determination – R squared for 1986 to 1992 was 0.478).

7.0 Retrospective Analysis of In-season Run Size Techniques

One of the most important components of an in-season salmon fishery management system is the estimate of returning run size. This figure determines the total number of salmon available for harvest. Managers rely upon these figures to schedule fishery openings, to ensure that catch is allocated among various user groups and to meet specified harvest rate targets or escapement goals. Errors in the process of estimating the run size can trigger or postpone commercial openings, which may lead to under or over-escapement to spawning grounds and/or fisheries closer to the natal rivers. Pre-Season forecasts and in-season run size estimates are also used by fishermen to make decisions regarding how they will allocate their effort among various fishing opportunities.

Many models have been developed for estimating returning run abundance. Run size estimates can be obtained from pre-season forecasts, commercial fisheries (catch and catch per unit effort (CPUE)), test fisheries and in combination with spawning escapement monitoring. The process of estimating run strength occurs over the length of migration, producing an array of run size estimates. The manager must then combine these estimates to produce a "best" estimate. Managers generally consider in-season estimates more reliable than pre-season estimates (Walters and Buckingham, 1975). A number of authors (Fried and Hilborn, 1988; Fried and Yuen, 1987; Henderson et al., 1987) have proposed and evaluated various techniques to both estimate run size and how to combine several independent indicators of run strength.

The purpose of this section is to:

1. Describe the models currently used for assessing the returning strength of chum salmon to the inside waters of southern British Columbia (Figure1.1)

2. Determine whether one model performs with more consistent accuracy than any of the others.

3. Finally to determine whether run size estimation can be improved by pooling results from independent models.

7.1 Methods

Model

Six models, one pre-season and five in-season, were constructed to forecast total stock size. The pre-season wild stock prediction for each year *i* from 1988 to 1997 was calculated by determining the average proportion of 3-, 4- and 5-year olds in the returning stock over the period 1980 to 1994. These proportions were based upon chum salmon scales collected from test and commercial fisheries in Johnstone Strait and the Fraser River. Next, the expected total return from years *i*-3, *i*-4 and *i*-5 was calculated by taking the product of the escapement and the return rate per spawner. The average proportion of age 3, 4 and 5's in the most recent 15 brood years (1979-1993) has been 17%, 70% and 13%, respectively. The average return per spawner over the same 15 brood years was 1.7:1.0. Finally, returns from each brood year were summed to produce the predicted wild run size for year *i*. For the enhanced component contribution to the total returning run size, run size was estimated by applying survival rates for each type of enhancement facility and the average return by age group, to the number of fry released by the facilities. The total return was then the sum of the wild and enhanced components.

The five in-season models all had the same structure of the form:

$$LN(\hat{Y})_{i,j} = LN\alpha + \beta LN(X)_{i,j}$$

where $\hat{Y}_{i,j}$ equals the predicted total run size estimated from data source *i* and time *j*, α = the y-axis intercept, β = slope of the regression line, and $X_{i,j}$= data from data source *i* for time period *j*. The five data sources for the in-season model are: (1) test fishing CPUE by week or cumulative CPUE; (2) total commercial catch (seine and gill net) in a Johnstone Strait fishery; (3) commercial seine gear catch in a Johnstone Strait fishery; (4) commercial seine gear CPUE; (5) pooled estimate combining a test fishery estimate with one of the other model estimates. Pooling was based upon the residual mean square error (RMS) (Hilborn and Walters, 1992).

$$\overline{R}_j = \sum_{i=1}^{2}[R_{i,j} \times (1/RMS_{i,j})] / \sum_{i=1}^{2}(1/RMS_{i,j})$$

where $\overline{R}_j$ = weighted mean run size for time *j*; $R_{i,j}$ = estimated run size for time *j* and method *i*; and $RMS_{i,j}1$ = residual mean square error from the linear regressions for time *j* and method *i* derived in equation (1).

A hindcasting procedure was used to examine the predicative capabilities of the various models. Only data prior to the year of interest was used to calculate the predictive equations. Simulations were conducted for the years 1988 to 1997. Run size estimates are classified into pre- and early-season, mid-season and final. The pre- and early season includes the pre-season forecast, test fishing results in the fourth week of September (9/4) and a commercial fishery held the same week. Mid-season includes cumulative test fishing CPUE from the fourth week of September to the second week of October (10/2) and any commercial fisheries held during the second week of October. The final estimate is derived from cumulative test fishing CPUE from the fourth week of September up to and including the third week of October (10/3) and any commercial fisheries held after the second week of October. Predictive regressions were only used if F-tests for the model were significant at the 95% level.

Three methods of comparing run size estimates were used: (1) annual percent error, (2) mean percent error (MPE); and (3) mean absolute percent error (MAPE). Annual percent error was calculated as:

$$[-(A_k - R_{i,j,k}) / A_k] \times 100$$

where A_k = actual run size in year *k* and $R_{i,j,k}$ = predicted run size for time *i* with model *j* and in year *k*. MPE provides for a measure of bias in any of the methods used; examining for persistent over- or under-estimates of run size. To assist in examination of the range and distribution of under-forecasting (negative MPE) and over-forecasting (positive MPE) bar charts were constructed. MAPE yields a measure of overall model performance with over- and under-estimates in run size treated equally.

7.2 *Results*

The size of the Clockwork chum salmon run varied from a low of 1,383,000 in 1997 to a high of 4,858,000 in 1994 over the ten years examined. Escapement range had less variation, ranging from a low of 980,000 in 1989 to over 2,812,000 wild spawners in 1994. The average total return during the ten years examined was 3,100,000. Clockwork chum salmon start to migrate through Johnstone Strait from about mid-September and the run is generally completed its migration through Johnstone Strait by about the end of October. The run timing as measured by cumulative test fishing CPUE in Johnstone Strait varies considerably among years, with the 1989 run arriving the earliest and the 1994 run the latest (Figure 7.1). The actual dates when 50% of the run had passed the Johnstone Strait test fishery ranged from October 2 in 1989 to October 19 in 1995. The mean 50% date pass the Johnstone Strait test fishery is October 11 for the years 1988 through 1997.

Pre- and Early Season

The accuracy of the various models tested (Pre-season, Test Fishing CPUE, Total Catch, Seine Catch and Seine CPUE) varied greatly both among and within years (Table 7.1 and 7.2). The pre-season forecast had the largest deviation from the true run size during the Pre- and Early Season time frame. In years 1995-1997 the pre-season forecast over estimated the true run size by 173%, 243% and 259%, respectively. The pre-season forecast produced the largest errors from the true run size; accounting for six out of the ten years examined. The test fishing model had three years that produced the largest magnitude in error from the true value and finally the seine CPUE model had one year in which its estimate produced the largest magnitude error from the true value.

With respect to overall model performance there was no single model that outperformed all the others. The MAPE's for all models ranged from a low of 9.4% for the Total Catch model to a high of 88.8% for the pre-season model. Most troubling was an overall tendency for all models to over-estimate the true run at this stage of the returning migration. Finally, the weighted model estimates had MPE and MAPE values that were lower or intermediate than those of its components.

Mid-season

Overall, the individual models improved in their forecasting ability from the earlier time frame as evidenced by a reduction in their MAPE value's. This improvement in forecasting ability was evidenced by large decreases in the RMS over the course of the season (Figure 7.2). The best model for estimating run size was the seine CPUE or seine catch. Both of these models outperformed either the cumulative test fishing or total commercial catch models. However, it should be observed during this time period there were only three years which had commercial fisheries to allow us to construct run size estimates.

There was still an overall over-estimate of the true run size, though to a much lesser degree than early in the run migration. As in the Pre- and Early Season time the weighted model estimates for this time frame had MPE and MAPE values that were lower or intermediate than those of its components.

End of Season

Once again, no single model performed consistently better than any of the others. For this time frame the weighted estimates performed slightly better than their individual components. As with the mid-season time frame there was a reduction in MAPE values from the pre- and early-season time frames. There was once again a tendency for the MPE values to be positive indicating a tendency to over-estimate the returning run size by all models. The cumulative test fishing model over-estimated 8 of years that we have estimates. The Total Catch and seine catch models had five out of six years and the seine CPUE model's had four out of six years that over-estimated the true run size.

7.3 Summary

The above analysis describes the current technique used to estimate the run strength of chum salmon returning to the 'Study Area'. The results show that no one single model examined in this paper outperformed any of the others. It did show though, that pooling of the individual estimates generally improved the overall accuracy and reduced the bias (as measured by MPE) of the run size estimates produced. This result is in agreement with results of Fried and Yuen (1987) who examined a similar pooling methodology for forecasting the returning sockeye salmon run strength to Bristol Bay, Alaska. Fried and Hilborn (1988) also examined Bayesian probability theory to produce in-season estimates for sockeye salmon returning to Bristol Bay, Alaska. They also found that while the Bayesian method was not always more accurate than the most accurate individual method, it was always more accurate than the least accurate individual method.

A number of findings in the present study have some results of interest to management of the 'Study Area' chum salmon fishery. Firstly, there is the generally poor performance of the pre-season forecast. Its utility for helping to manage Clockwork stocks is extremely questionable. This was extremely evident during 1995-97 when the pre-season forecast was greater than 4.2 million and the actual return was less than 1.5 million. Second, there was the noted result of over-estimating the actual magnitude of the returning Clockwork chum salmon run size. This tendency to over-estimate persists over the three time strata examined, but was at a minimum during the peak of the run. This tendency to over-estimate has the potential effect of scheduling additional harvest when it doesn't exist. This is particularly noticeable in 1989 when the run timing 50% date was October 2 (Fig. 7.1). The mean 50% date is about October 11 (95% C.L. of 5 days). While this explains the initial over-estimation early in the season it does not explain the continuing over-estimation of run size throughout the fishing season.

The third important finding from this analysis is that while the MAPE averaged 12-20% using the commercial fishery models at the peak of the season there was still 4 years out 10 that over-estimated the run size by 60-70% with the test fishing models. While the current models have a tendency to over-estimate the run size and potentially create a 'paper' surplus, the stepped harvest rate management regime in place for the Clockwork chum salmon ameliorates the over-estimation problem. When the levels for the various harvest rates were being developed it was recognized that in-season estimates not very reliable and consequently conservative harvest rates were set. For example, in 1995 the run size was consistently over-estimated with the mid-season estimate of 2.5 million versus an actual return of only 1.5 million or an over-estimate of 62%. However, since the first harvest step of 20% doesn't take effect until run sizes of greater than 3.0 million are estimated, no fisheries were scheduled.

All the models examined in the present study require estimates of catch and escapement. Naturally, the reliability of these models will depend upon the quality of these data. While the catch statistics are considered reasonably easy and consistently collected, the same cannot be said for the escapement data. As pointed out earlier, there are a large number of streams contributing to the 'Study Area' chum salmon and a wide variety of escapement methodologies applied. These escapement methodologies range from foot or aerial surveys, to mark recapture and also fences on some systems. The increased uncertainty in both catch and escapement will affect the results in this study.

8.0 Review of Fishery Management 1983-1997

8.1 Management Objectives

Management of ISA chum stocks is governed by:

- The optimum wild escapement: hypothesized to by about 2.5 million spawners based upon habitat capacity (Palmer 1972, Fraser et al. 1974) and stock recruitment analysis (Beacham 1984 and Luedke, 1990). This includes an escapement of 700,000 for Fraser River.
- Reach the optimum wild escapement within 12 to 15 years.
- Allow limited fishing at low stock size.
- Stabilize the annual catch. There should be few years with no fishing.
- Determine how accurate the estimated optima escapement of 2.5 spawners is by allowing for escapements larger than the 2.5 million.

Prior to 1983 the management of Johnstone Strait and Fraser River chum fisheries were set based upon a fixed escapement strategy. Chum salmon recruitment is quite variable and with a fixed escapement approach applied to a variable recruitment results in large harvest variability.

A stepped harvest plan allows for more flexibility in the spawning targets, thereby allowing for some harvest in most years. The stepped harvest plan schedule for Clockwork applied to

Johnstone Strait fisheries after September 1 (Figure 8.1). The Johnstone Strait harvest steps currently in place are:

Wild Stock[1]	**Total Stock**[2]	**Harvest Rate**
0.0 – 2.0 million	0.0 – 3.0 million	10%[3]
2.0 – 2.9	3.0 – 3.9	20%
2.9 – 4.2	3.9 – 5.2	30%
over 4.2	over 5.2	40%

[1] *Wild stock includes populations with at least 25% of the return from wild spawning.*

[2] *Total stock equals wild plus enhanced plus U.S. components. During 1987 to 1998 the preseason expected enhanced component has been set at 900,000, but may vary dependent upon HEB expectations. U.S. component was set at 100,000.*

[3] *The 10% harvest rate includes non-commercial catch, commercial fisheries and test fisheries. At a stock size below 3.0 million, commercial fisheries in Johnstone Strait would not be scheduled after the September assessment fishery.*

As presented in the previous section the magnitude of the returning run is assessed by three methods. First, is the pre-season forecast derived from returns/spawner, fry survival, etc. Second, correlation between commercial fishery catch and total run size. Lastly, correlation between the Johnstone Strait test fishery catch and total run size.

This section will attempt to address three basic questions in order to assess the effectiveness of the Clockwork management plan:

1. Given the in-season run size assessment was the desired fishery objective achieved?
2. How accurate was the in-season assessment in relation to desired and actual harvest rates?
3. Are the escapement levels both from Johnstone Strait and on the spawning grounds assumed in-season actually being met?

The next two paragraphs answer the above three questions from the viewpoint of existing goals and the third paragraph re-examines the appropriateness of the goals.

Figure 8.2a shows the estimated desired harvest rate based upon the in-season estimate of stock size and the actual in–season harvest rate. There are two instances where the in-season estimate of harvest rate is much larger than the desired; 1989 and 1990. In both years the run size was over-estimated in-season resulting in further fishing opportunities. In 1995, run size assessment late in the season resulted in estimating a run size of 3.o million up from previous estimates. This re-evaluation moved the harvest rate from 10% to 20% and provided a fishing opportunity.

From the in-season point of view it would appear that in-season assessment failed. Overall though, comparison of the actual and desired harvest rates over the 15 years suggests with the information available in-season, the fisheries are being managed fairly well from the in-season point of view.

The next comparison is of post-season desired and actual harvest rates (Figure 8.2b) reveals we were somewhat less successful in achieving our harvest rate goals. In four years (1986, 1988, 1989 and 1990) the actual greatly exceeds the desired harvest rate. From 1992 onwards, the post-season actual and desired harvest rates track each other quite well. The close agreement in actual versus desired harvest rates from 1992 onwards occurred over both large and small run sizes. The improved results from 1992 onwards, may partly be due to modification of the in-season run size estimation procedure starting in 1993. Firstly, the pre-season forecast was removed from the in-season calculation of run size and secondly the in-season run sizes estimates from independent models were combined using the inverse of their variances as weights (PSARC 95-08).

Figure 8.2c is a comparison between post-season escapement from Johnstone Strait as a result of the actual and desired harvest rates. This comparison would indicate that the management and stock assessment system in place is achieving the prescribed escapements from Johnstone Strait quite well. Finally there is a comparison between wild escapement and the goal (Fig 8.2d). Total escapement was increasing during the late 1970s and early 1980s; with a peak in 1985 (Table 5.2). They then declined until a low was reached in 1989. Escapements then increased for several years, reached a second peak in 1994 and then declined in 1996 and 1997 due to very low returns. Preliminary indications for 1998 escapement are indicative of a wild escapement much greater than 2.0 million. Casual observation might lead one to conclude that the since the escapement goal was not met in 7 out of 15 years that the Clockwork plan is not succeeding. However, natural variability in returning stock strength prevents reaching the wild escapement goal when the actual total return is less than 2.0 million. The measure of success is then whether the stock assessment capabilities where able to discern the true stock size and allow managers to implement the correct fishery action. When figure 8.2c is examined from that perspective it would then appear that there where few years where escapements to the wild spawning grounds could have been significantly increased by reducing harvest.

8.2 Trends in Stock Production

Since the initiation of the Clockwork management program in 1983 and increased enhanced production from 1985 onwards there has been an increase in returns (Figure 8.3). The total wild average production from 1968-82 was 2.1 million and 1983-97 was 2.4 million. All of the increase in production was due to the Fraser River component of Clockwork stock. Fraser River chum average return increased 800,000 (1968-1982) to 1.3 million (1983-1996) or a 63% increase. In contrast we observed a slight decrease for the Canadian non-Fraser wild of 15%. The average return for this group was 1.3 million during 1968-82 and 1.1 million for the years 1983-96.

It was hypothesized that implementation of the Clockwork management regime in 1983 may result in temporary or permanent changes in salmon production and abundance in the related riverine or oceanic systems. To determine the impact of future fishery management decision, it is vital to quantify the past interventions on the system and then rational decisions can be made to ensure the management goals can be achieved. However available historical data are time series structured, this implies that the time series analysis, instead of traditional statistical methods, should be implemented. The general model to describe the time series with interventions is so-called the transfer function noise (TFN) model. In this section, the time series intervention analysis is introduced to demonstrate the impact for fishery policy on chum salmon production in British Columbia.

Model

We employ following TFN model (Box and Tiao 1975):

$$\mathbf{R}_t = \mathbf{f}(\mathbf{x}_t, \mathbf{I}_t, \boldsymbol{\beta}) + \mathbf{N}_t \qquad (1)$$

where $\mathbf{R}_t$ is the chum salmon production time series at year t. $\mathbf{f}(\mathbf{x}_t, \mathbf{I}_t, \boldsymbol{\beta})$ is the deterministic component of response $\mathbf{R}_t$, which includes a set of exogenous covariate series $\mathbf{x}_t$ and a set of intervention series $\mathbf{I}_t$ and the unknown parameter $\boldsymbol{\beta}$. $\mathbf{N}_t$ represents the stochastic noise series, which may be autocorrelated. To simplify our discussion, we make choice of $\mathbf{f}(\mathbf{x}_t, \mathbf{I}_t, \boldsymbol{\beta}) = \boldsymbol{\mu} + \boldsymbol{\beta}\mathbf{I}_t$, where $\mathbf{I}_t$ is the covariate to describe the fishery policy intervention under year 1983, which is defined as $\mathbf{I}_t = 0$ if $t < 1983$ or 1 if $t \geq 1983$. Parameter $\boldsymbol{\mu}$ is to describe the mean of the chum salmon production and $\boldsymbol{\beta}$ is the parameter to measure the mean shift before and after intervention. The stochastic noise series $\mathbf{N}_t$ in (eq 1) can be expressed as $\mathbf{N}_t = \mathbf{R}_t - \mathbf{f}(\mathbf{x}_t, \mathbf{I}_t, \boldsymbol{\beta})$. It may be modeled as typical mixtures of autoregressive integrated moving-average (ARIMA) models. This type of model associates the current observed chum salmon production value to the observed in the past, which is the fact in the fisheries where the fish abundance or production now is closely related to the abundance or production in the same stock in the past. The mathematical form for ARIMA model is defined as follows:

$$\boldsymbol{\phi}(\mathbf{B})\nabla^{d}\mathbf{N}_t = \boldsymbol{\theta}(\mathbf{B})\boldsymbol{\varepsilon}_t \qquad (2)$$

where B is the backshift operator, $\phi(B) = 1 - \phi_1 B - \dots - \phi p B^p$, $\theta(B) = 1 - \theta_1 B - \dots - \theta q B^q$, $\nabla^d = (1-B)^d$. This model is denoted by ARIMA (p, d, q). The special case of ARIMA (0,0,0) implies that time series observations are independent.

Box and Jenkins (1976) developed a paradigm for fitting ARIMA models, which is to iterate the three basic steps: a) model identification, b) estimation of model parameters and c) model diagnostics. Model identification step is to determine the ARIMA model orders (p,d,q). Several criterions can be used in this step. In the initial model identification stage, the autocorrelation function (ACF) and the partial autocorrelation function (PACF) as well as the associated 95% confidence band can be used. An overall procedure is to use a penalized log-likelihood measure. One of such measure is the well-known Akaike's Information Criterion (AIC)(Akaike 1974) defined as: AIC=-2(maximized log likelihood function)+2k, where k is the number of parameters being estimated. The smaller the AIC, the better the model fitted. If the AIC is used for the model identification, the maximum likelihood estimation should be used to estimate the model parameters and the associated standard error. The residuals can be used for model diagnostics, which should behave approximately as white noise.

Analysis

The chum salmon production time series data is illustrated in Figure 8.3. In the figure, the horizontal dashed line is the grand mean of the time series and the solid line is the mean before and after the implementation of the fishery policy for Fraser River, non-Fraser rivers and the total. It can be seen that the mean production appears to have been shifted by the fishery policy intervention. More specifically, the mean production in Fraser River is largely increased. However the mean production for non-Fraser River has declined slightly. The combination of the two results in an overall slight increase for the total chum production. The question we try to address is whether this mean change is statistically significant. The time series intervention model presented above provides a viable tool to address this question.

We started with N_t in equation 1 to be white noise, i.e. ARIMA (0,0,0), the estimated model parameters can be seen from Table 8.1. We analyzed the auto-correlation function, partial auto-correlation function and the associated 95% confidence intervals of the residuals for ARIMA (0,0,0). There were no significant indications for time series correlation. As a further confirmation, we fitted the data to intervention models of ARIMA (1,0,0) and ARIMA (0,0,1). The summary of model parameter estimates, variance estimates and the AIC values are presented in Table 8.1. All the parameters for auto-regressive and moving-average were not statistically significantly different from zero (t-value <1). The overall evaluation based on the AIC criterion persuaded us to use the simple ARIMA (0,0,0) model. Based on this model, it can be concluded that the intervention of fishery policy is statistically significant (t-value=3.579) for Fraser River chum salmon production, but not significant for non-Fraser River (t-value=-0.533) and the total production (t-value=1.266) chum salmon.

The high productions in the year 1972 and 1973 make the mean production before the intervention high. To study the impact of these two high production years, we analyzed the data from 1974 to 1996 using the same approach. The overall performance tended to still allow us to use the ARIMA(0,0,0) model. The intervention parameter β is now more significant than the analysis to use the data from 1968 to 1996. The summary is presented in Table 8.2 and the plot can be seen from Figure 8.4. Although the intervention parameter β is still not statistically significant for Non-Fraser and Total production, however the β is changed from negative to positive for Non-Fraser production, which indicates a slight mean production increasing instead of decreasing. Also the β parameter for the Total production is increased 87% from 0.300(million) to 0.562(million).

9.0 General Conclusions and Recommendations

The results of our review would indicate that overall the Clockwork management has been successful in achieving a number of its objectives. Namely the strategy has allowed for limited commercial fishing in most years, increased wild escapement levels overall and helped to increase our understanding of the optimal target escapement levels. That said, there remains significant concern over the level of escapement enumeration and accuracy of the escapement estimates upon which the Clockwork strategy and this stock status review depends. We believe significant improvements are required for chum escapement enumeration. We have noted earlier in this document that this is occurring in some areas and we strongly support the continuance and development of those programs. In 1998, preliminary escapement estimates to the Fraser River are in the order of 3.4 million and significantly greater than the current target of 700,000. The in-season Albion test fishery escapement estimate of 1.4 million was less than 50% of the post-season. This apparent disparity between the two should cause concern for managers of Fraser River chum. We recommend that a PSARC review of the programs used to estimate Fraser River escapement is required.

While there is a general increase in wild escapement levels, it would appear that not all areas have responded equally. Specifically, escapement records to Upper Vancouver Island, Kingcome Inlet, Bond and Knight Inlets and Toba Inlet show apparent declines to escapement levels. We caution in arriving at the conclusion that over harvest is the cause of the decline. Other factors such as lack of escapement enumeration effort to some of these areas and possible habitat issues may be the agent and this needs to be explored in greater detail.

The current wild escapement goal is set at 2.0 million. The Clockwork management plan called for reaching the interim goal of 2.5 million in 12-15 years or 1995-1998. Results from the present stock-recruit analysis suggests the Smsy level is 740,000 (479,000 – 2,482,000; 80% CL) for Fraser River chum. Recent record escapement will allow us to test this conclusion in the near future. At this time we recommend no change to the current minimum escapement target for Fraser River of 700,000. With respect to the overall goal, our analysis was significantly divergent from Beacham's (1984). This result is not surprising given the increase in the number of years available for inclusion in our analysis. Anecdotal information would suggest that the 1985 brood year should be removed from the analysis due to atypical freshwater mortality and thus the high escapement in 1985 produced extremely low recruitment. When the 1985 brood was removed from the analysis the estimate of optimal escapement was 2.4 million. As we have 4 more years (1993-1996 and 1998) of estimated escapement above or near 2.0 million that cannot as yet be included in the analysis we recommend leaving the wild escapement goal at 2.0 million until such time these additional years can be included.

Finally, while in-season estimates of run size have provided reasonably accurate estimate in comparison to the final run size estimates. There has been a number of years where the in-season and final estimate were significantly divergent. The current models are dependent upon the assumption of average migratory timing of the Clockwork chum stocks. In-season models based upon average migratory timing will under or over-forecast population abundance's because of run timing variability. Recent analysis by Zheng and Mathisen (1998) that incorporates a run timing variable found greatly improved run size forecasts for southeastern Alaska pink salmon. They found that incorporating sex ratios with their best performing run model improved forecasts by 30% over the best model without sex ratios. We have been collecting sex ratio data for chum Clockwork stocks since 1993 and preliminary analysis indicates that there is a correlation between sex ratios and run timing as observed by the

Johnstone Strait chum test fishery vessels. Therefore we recommend that further analysis be considered to incorporate sex ratio data into the in-season run size models.

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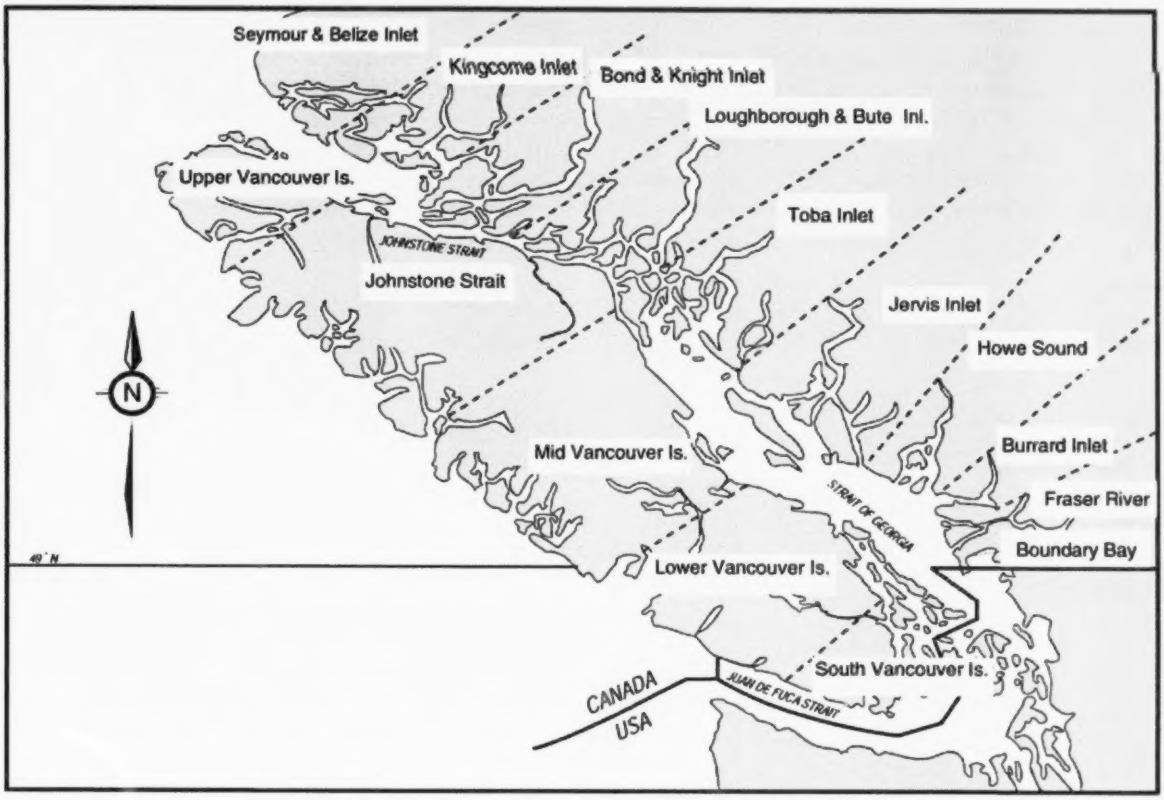

Seymour & Belize Inlet
Kingcome Inlet
Bond & Knight Inlet
Loughborough & Bute Inl.
Upper Vancouver Is.
Toba Inlet
JOHNSTONE STRAIT
Johnstone Strait
Jervis Inlet
Howe Sound
N
Burrard Inlet
Mid Vancouver Is.
Fraser River
STRAIT OF GEORGIA
Boundary Bay
49° N
Lower Vancouver Is.
South Vancouver Is.
CANADA
USA
JUAN DE FUCA STRAIT

Figure 1.1. The fifteen major geographic regions for Inner South Coast Chum Salmon stock groups. Chum stocks in Seymour and Belize Inlets (Area 11) and those below Saanich Inlet (Areas 19 and 20) in South Vancouver Island are not included in the Inner Study Area or Clockwork Management Strategy.

Figure 1.2. Trends in catch and escapement for Clockwork chum stocks from 1953 to 1997.

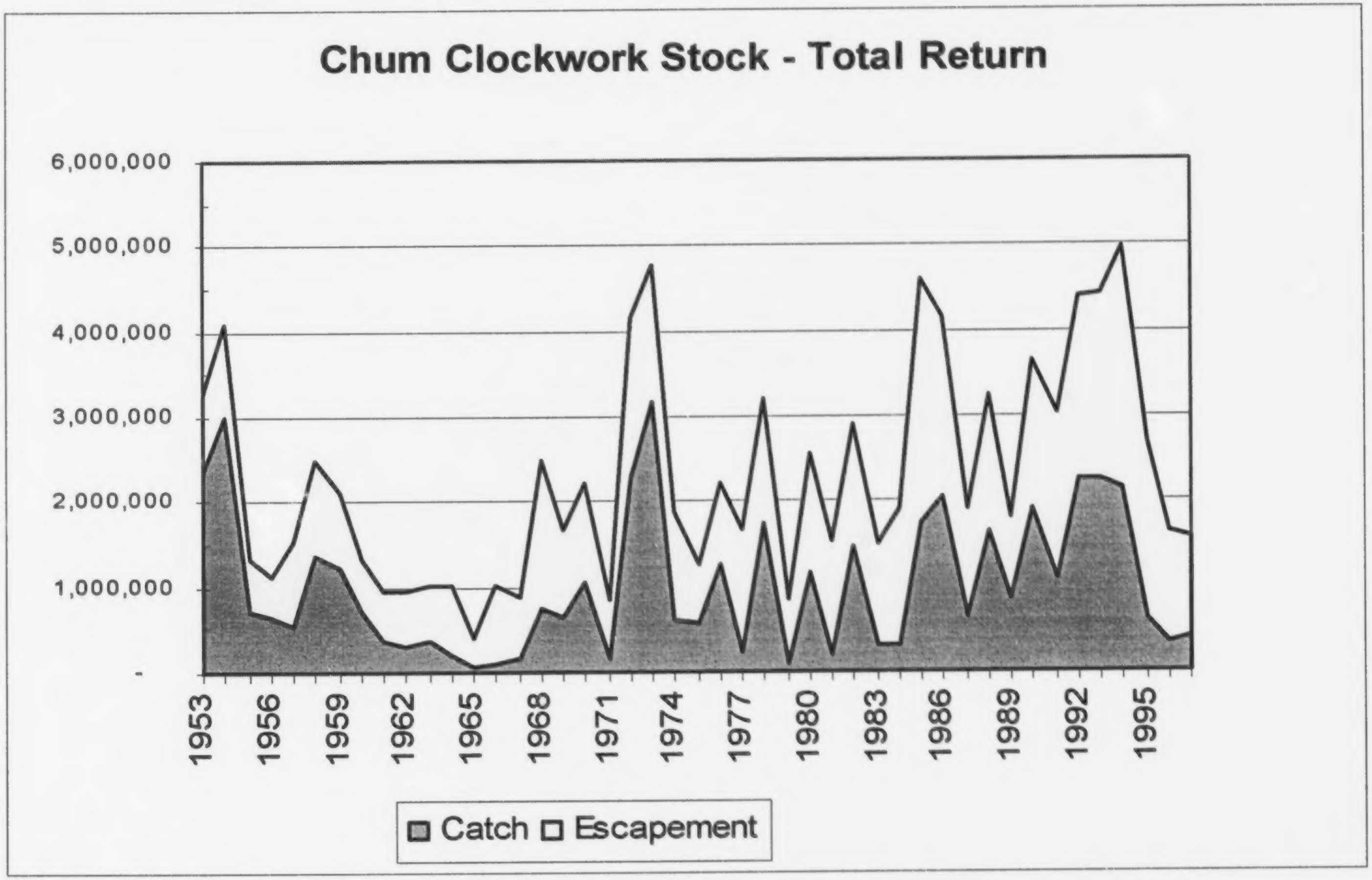
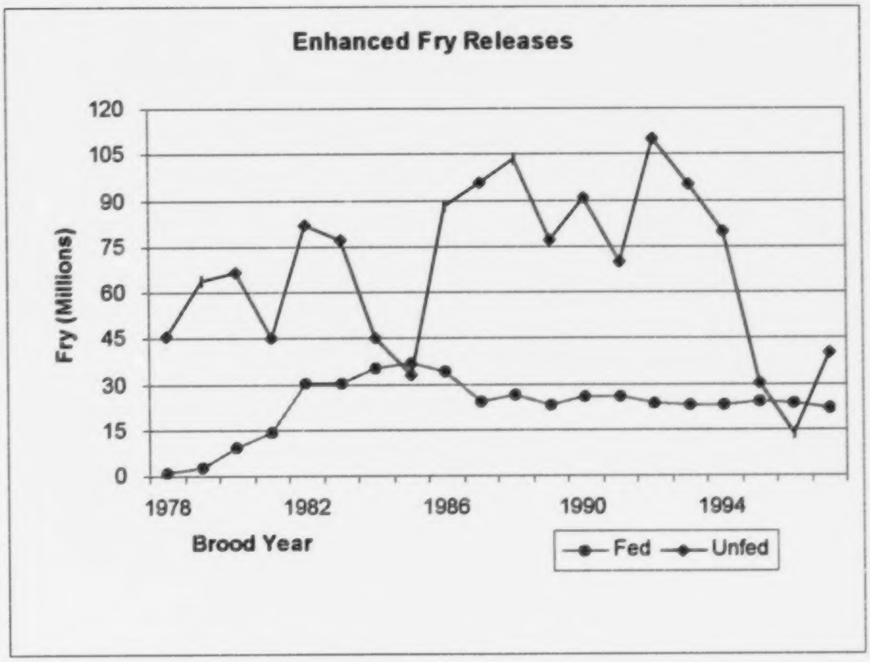


Figure 3.1 Inner South Coast enhanced fed and unfed juvenile releases (1979-1997 Brood)



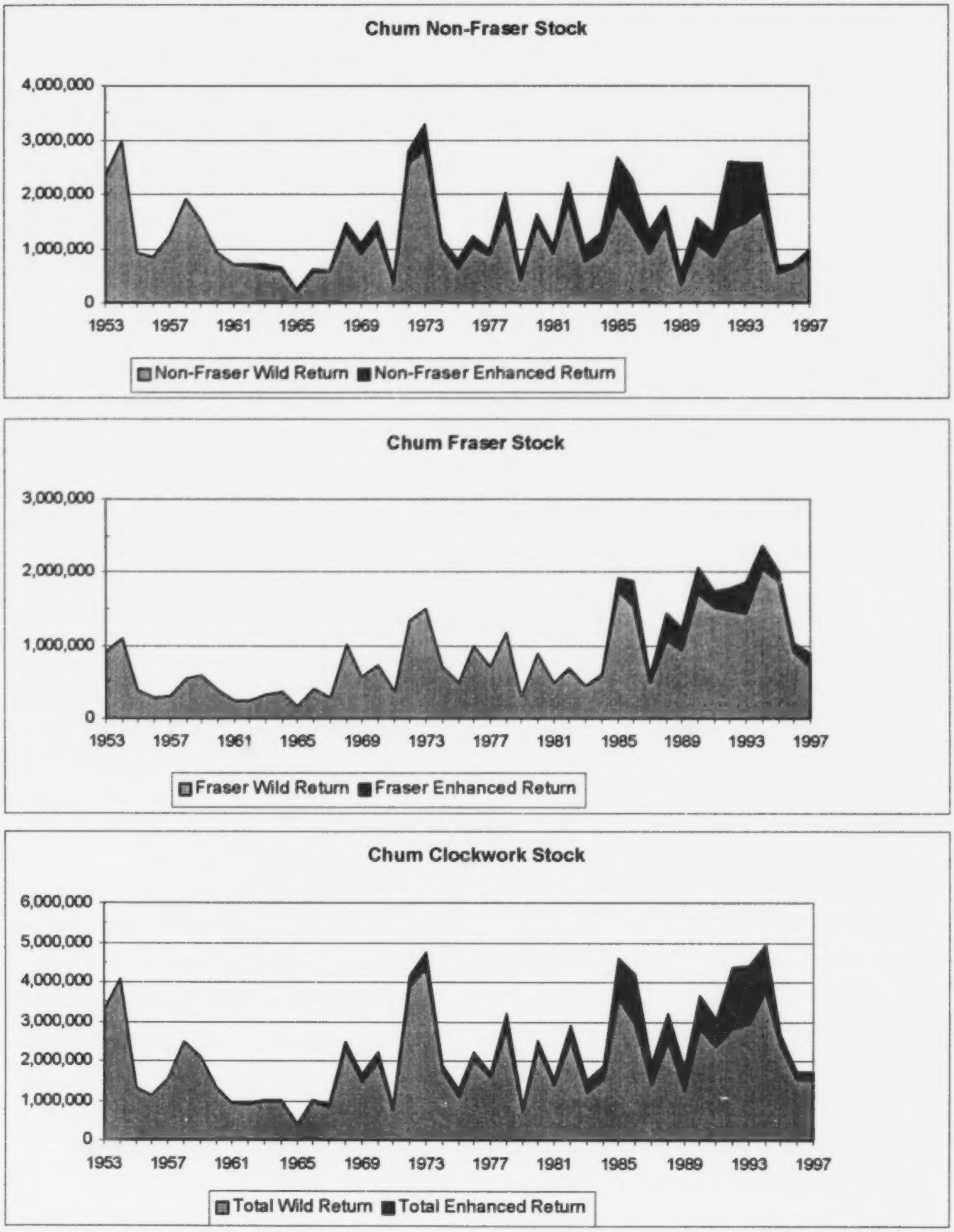


Figure 3.2 Inner South Coast Non-Fraser and Fraser wild and enhanced total chum returns (1953-97)

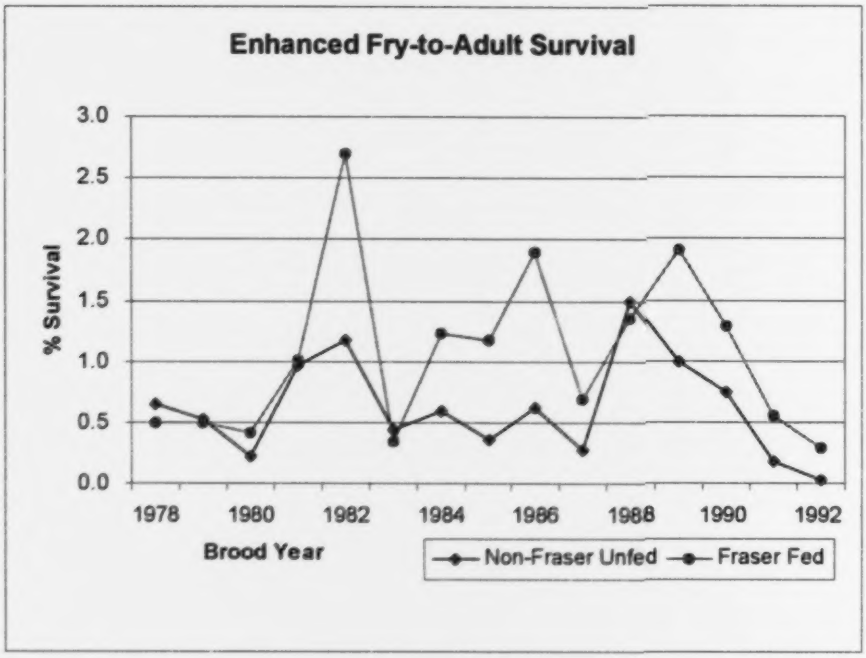


Figure 3.3 Fry-to-adult survivals for Inner South Coast enhanced fed and unfed chum (1978-1992 Broods)

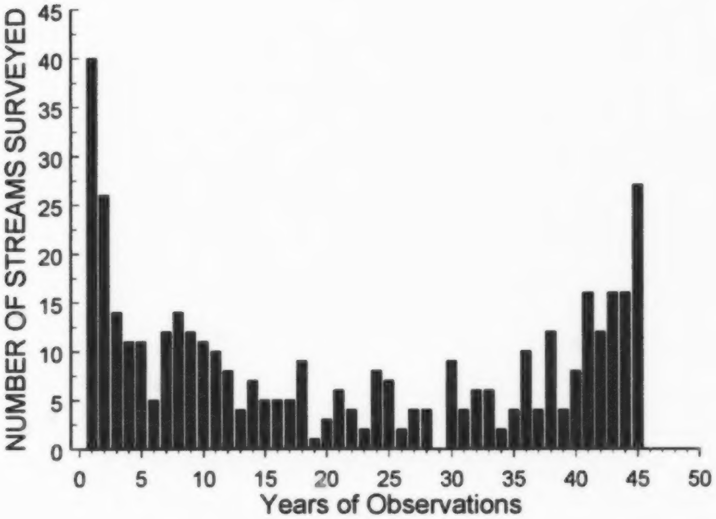


Figure 4.1 Distribution of the number of observations for Inner South Coast Chum salmon stocks from 1953 to 1997. Maximum number of observations is 45.

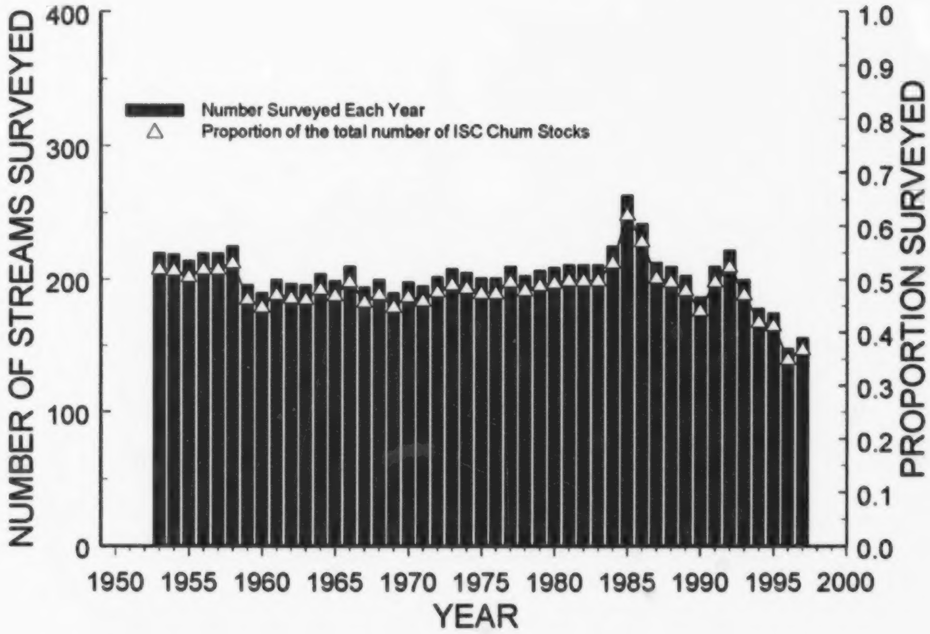


Figure 4.2 History of escapement surveys for Inner South Coast chum salmon from 1953 to 1997. Bar graph represents the number of streams surveyed each year. Line graph is the proportion of the total number (423) chum salmon stocks in the Inner South Coast with at least one chum salmon escapement estimate in the Salmon Escapement Database.

Figure 4.3 Relationship between total escapement contributed by each stock with at least one chum salmon escapement estimate in the Salmon Escapement Database and the total number of Inner South Coast chum stocks (423) for 1953-59 and 1990-97.

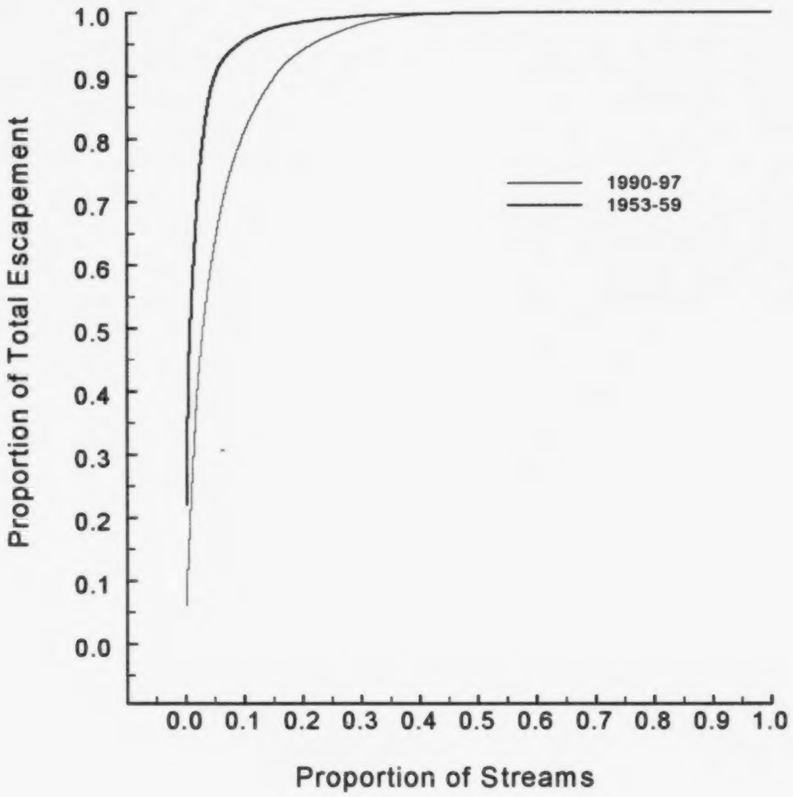


Figure 4.4 A) Wild escapement and B) standardized escapement trends for Inner South Coast Chum Salmon. Wild target escapement levels are shown for each region and the estimated wild capacities are shown for most regions. Zero line on B) represents the grand mean for each geographic area from 1953 to 1997. Dashed line is a lowess-smoothed curve.

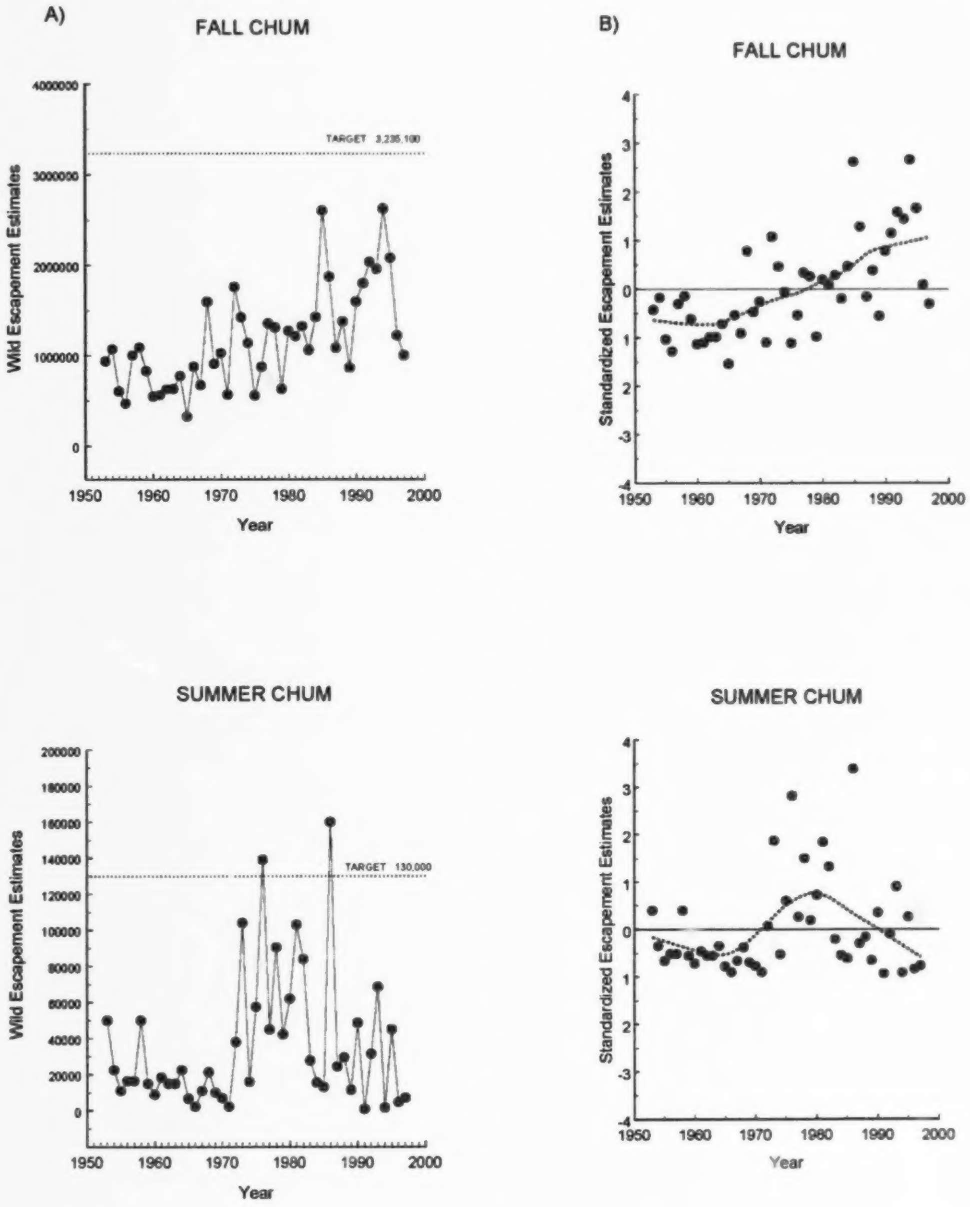
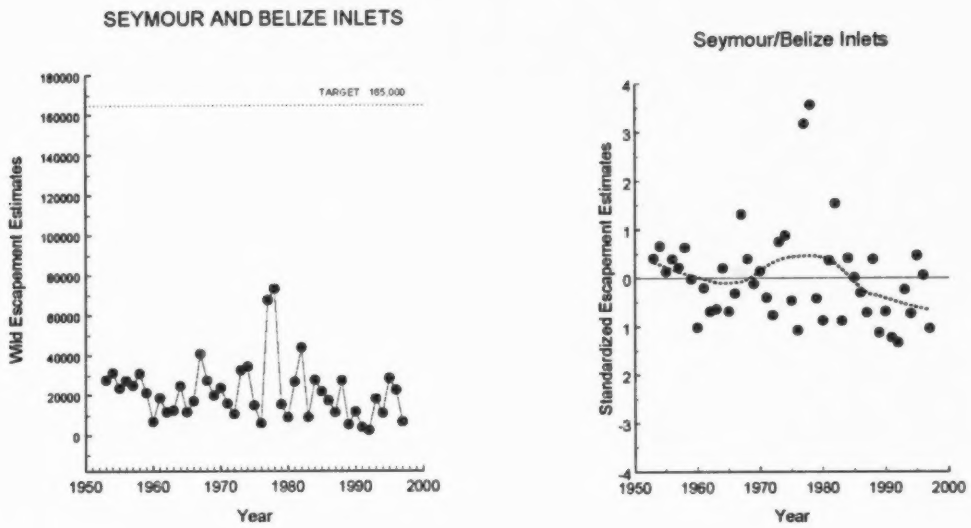
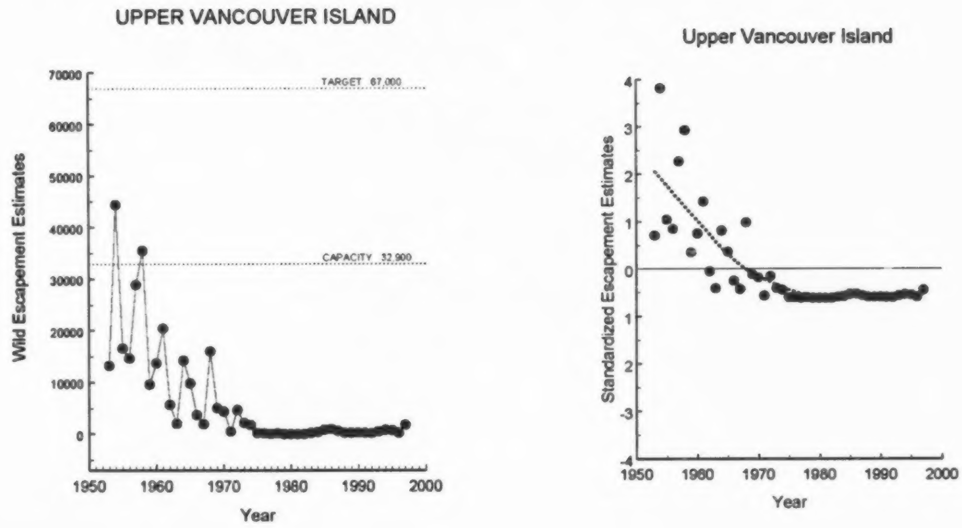


Figure 4.4 Continued



SEYMOUR AND BELIZE INLETS

Seymour/Belize Inlets



UPPER VANCOUVER ISLAND

Upper Vancouver Island

Figure 4.4 Continued

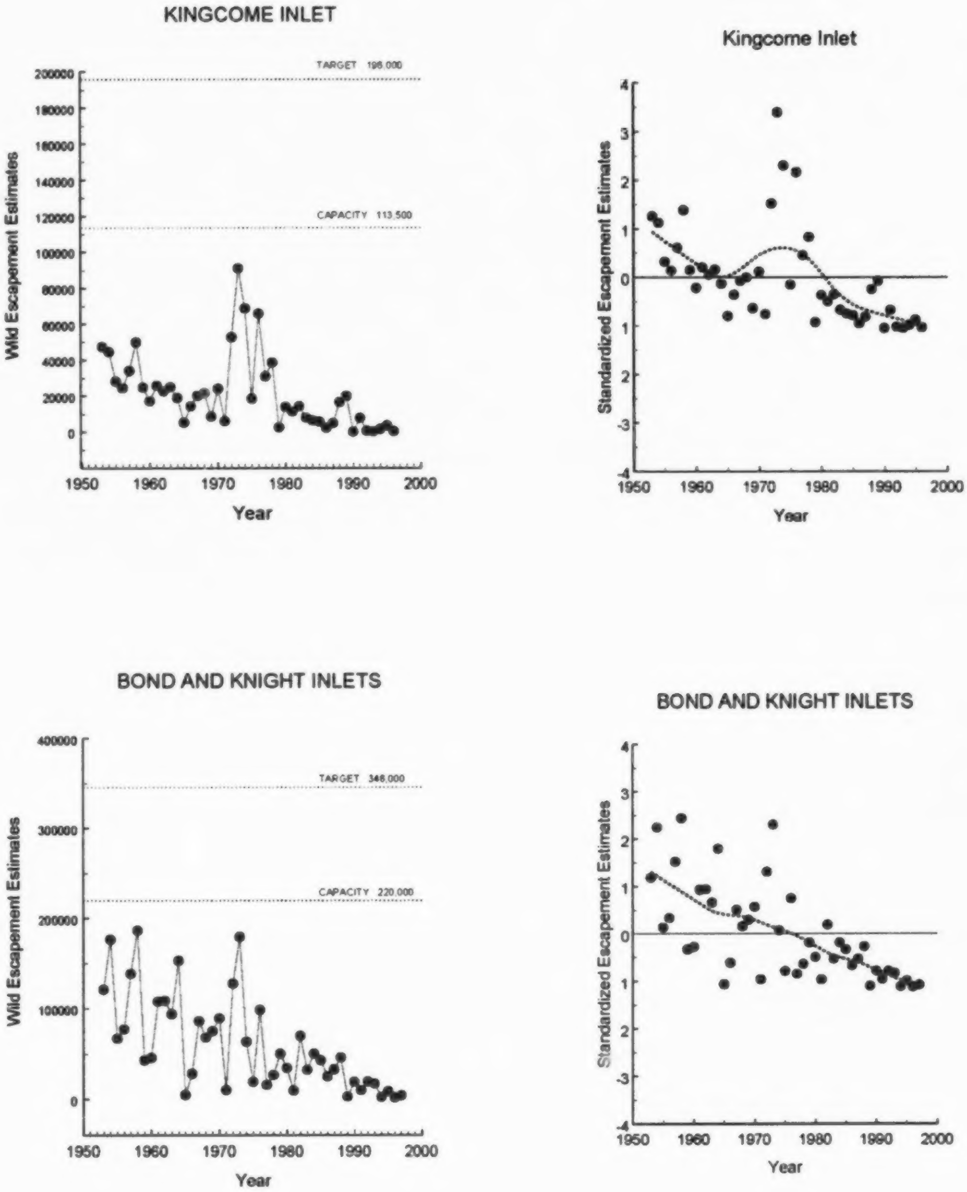
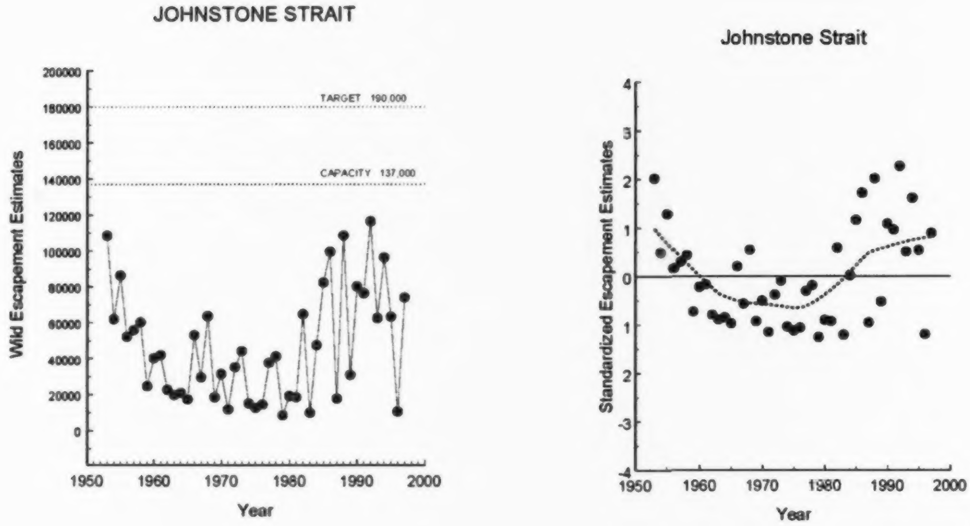
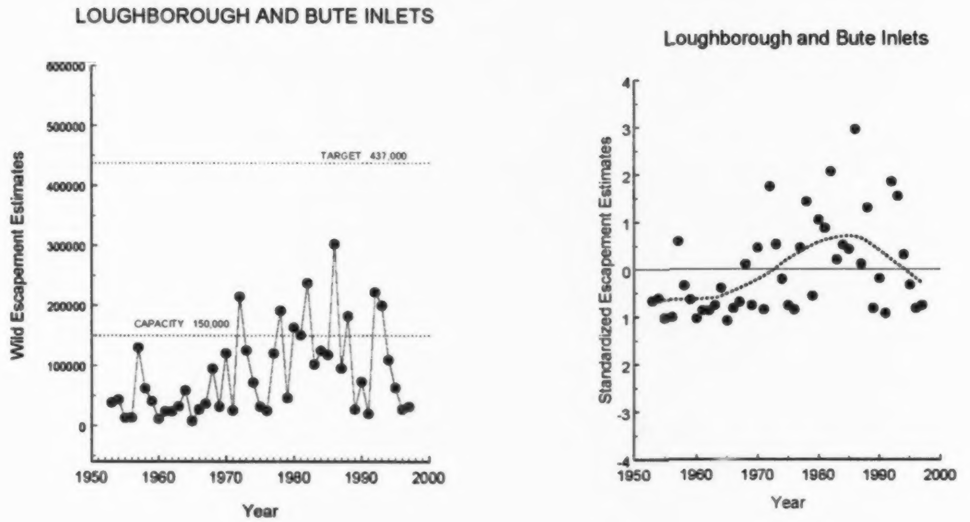


Figure 4.4 Continued



JOHNSTONE STRAIT

Johnstone Strait



LOUGHBOROUGH AND BUTE INLETS

Loughborough and Bute Inlets

Figure 4.4 Continued

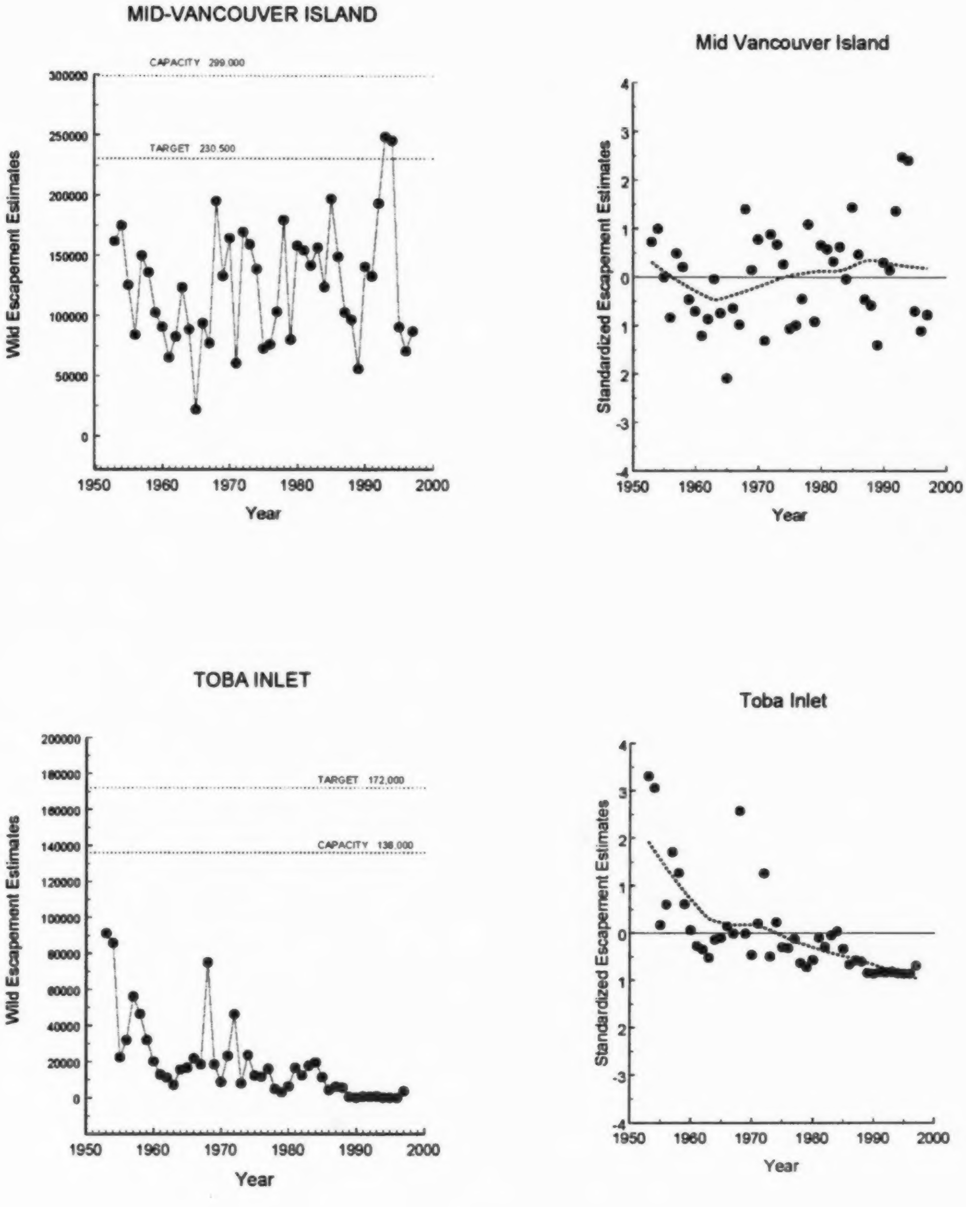
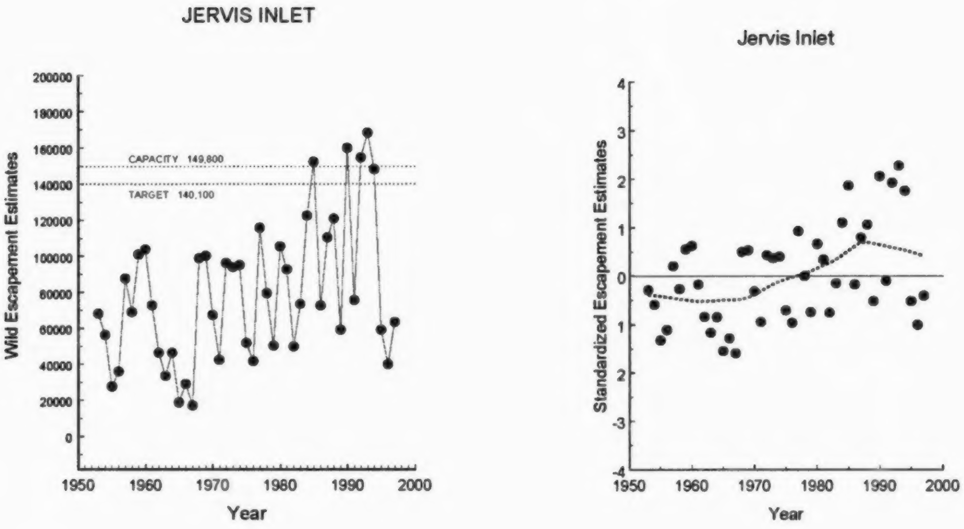
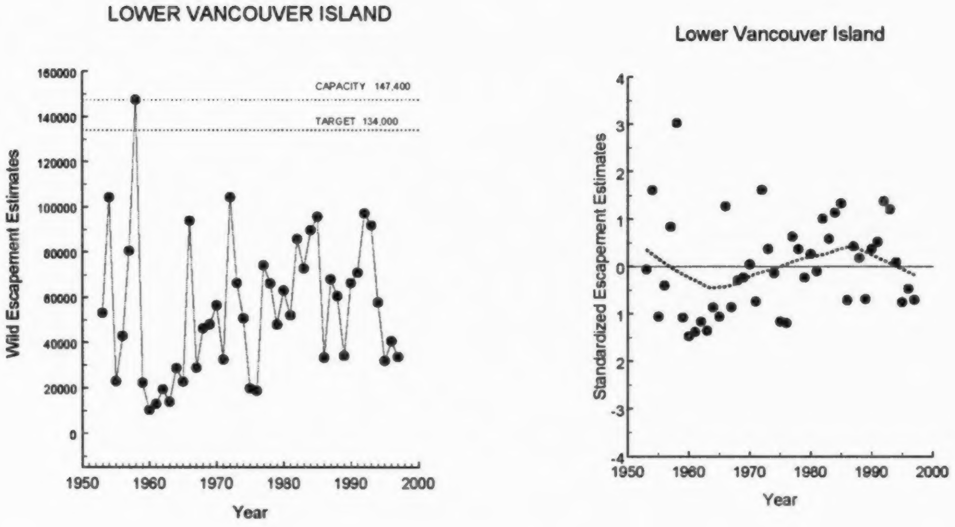


Figure 4.4 Continued


JERVIS INLET

Jervis Inlet


LOWER VANCOUVER ISLAND

Lower Vancouver Island

Figure 4.4 Continued

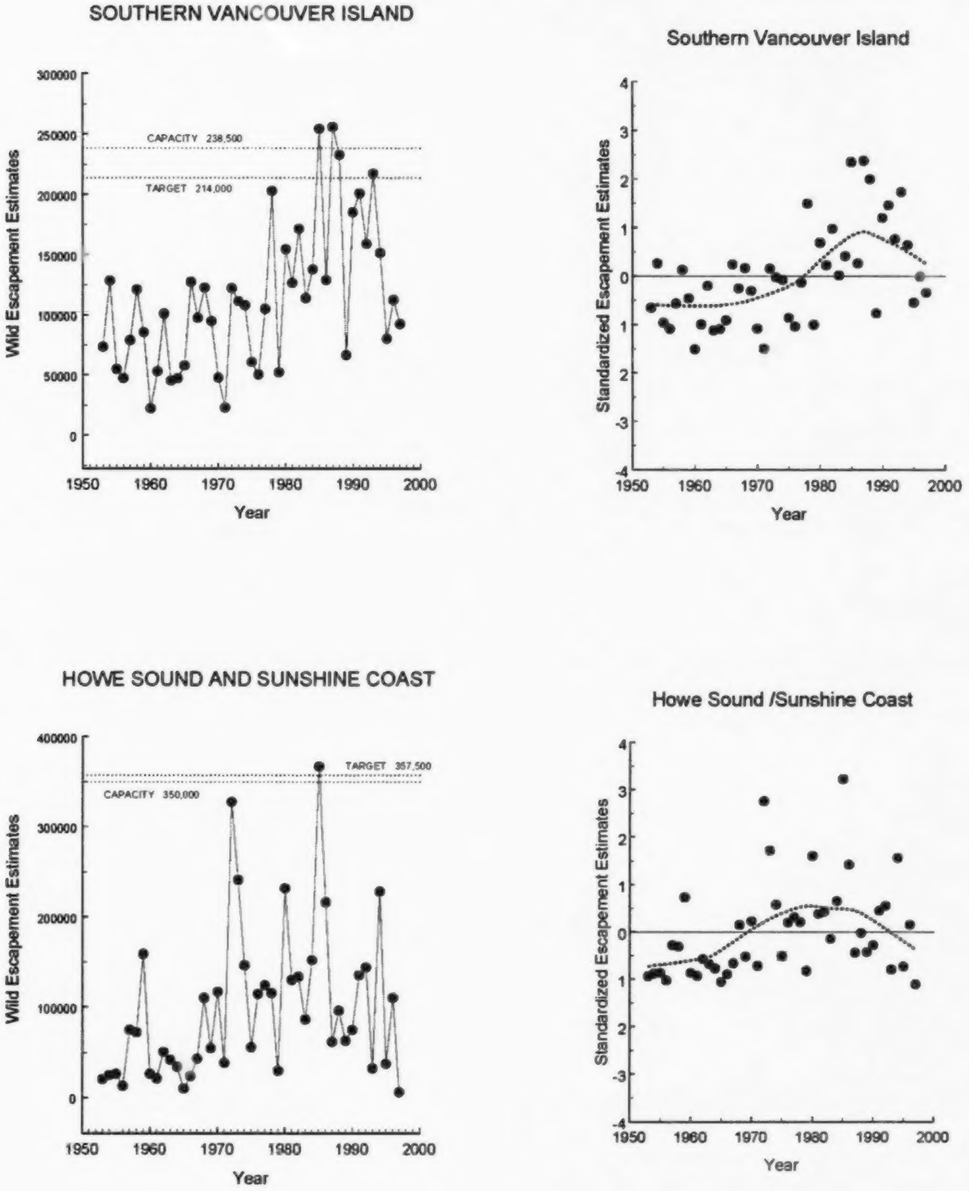
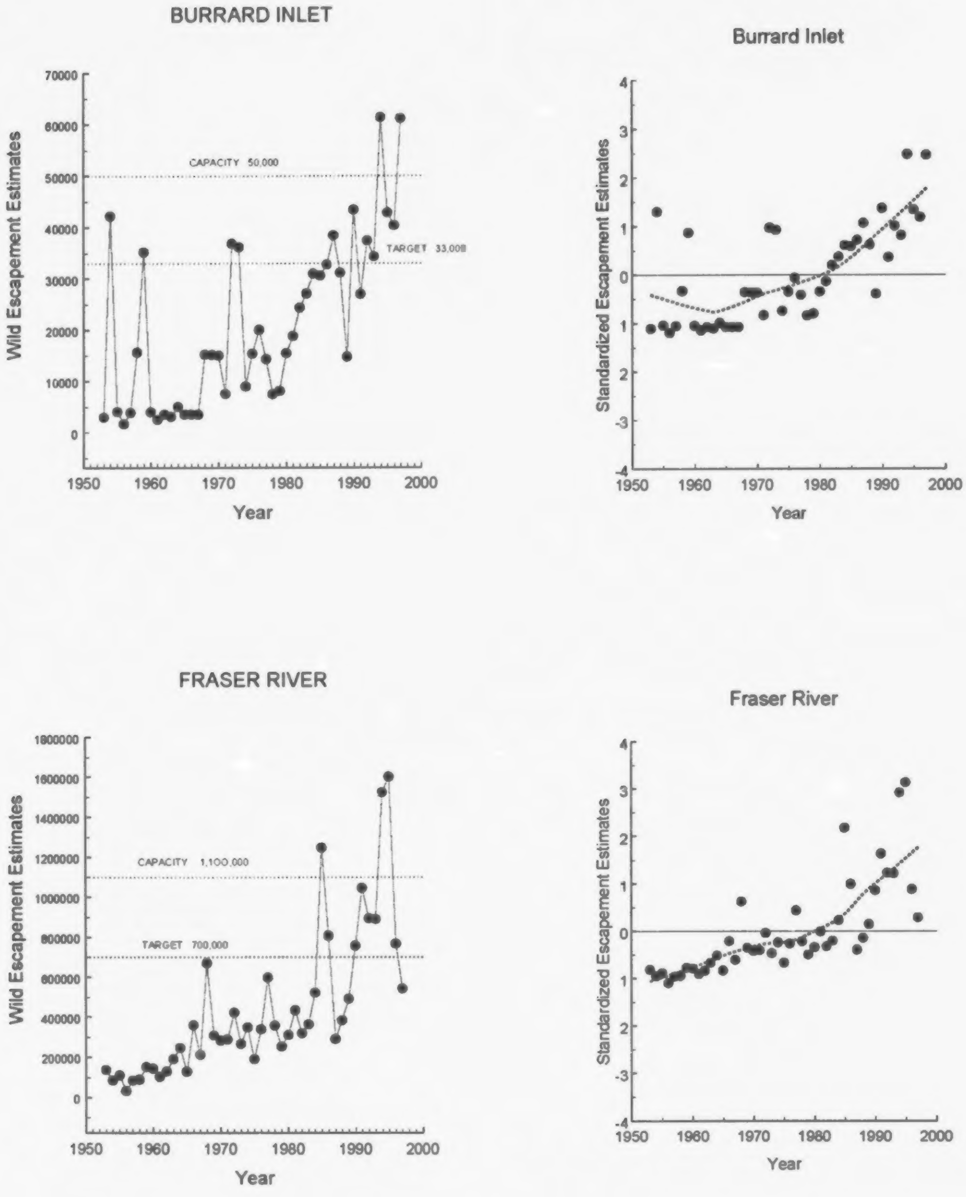


Figure 4.4 Continued



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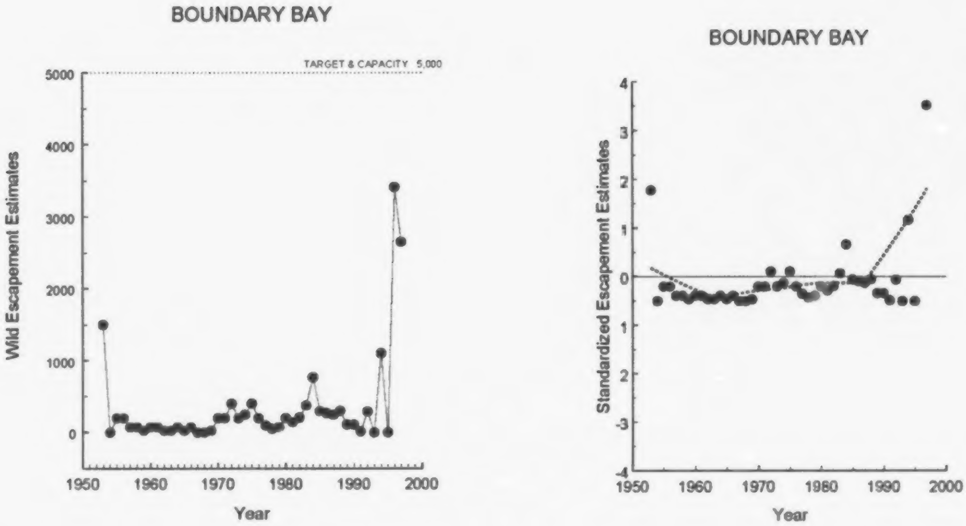
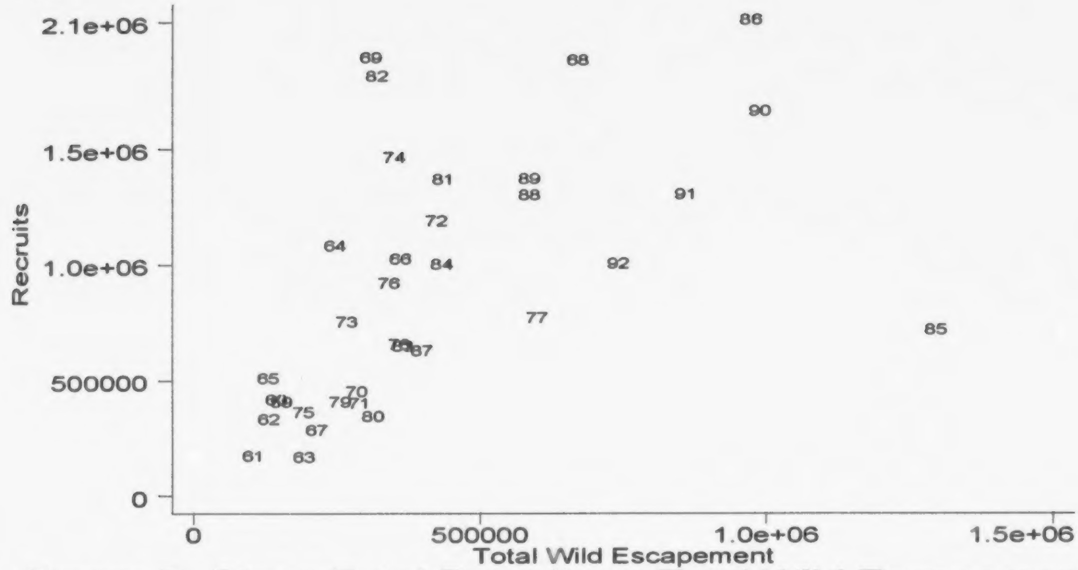
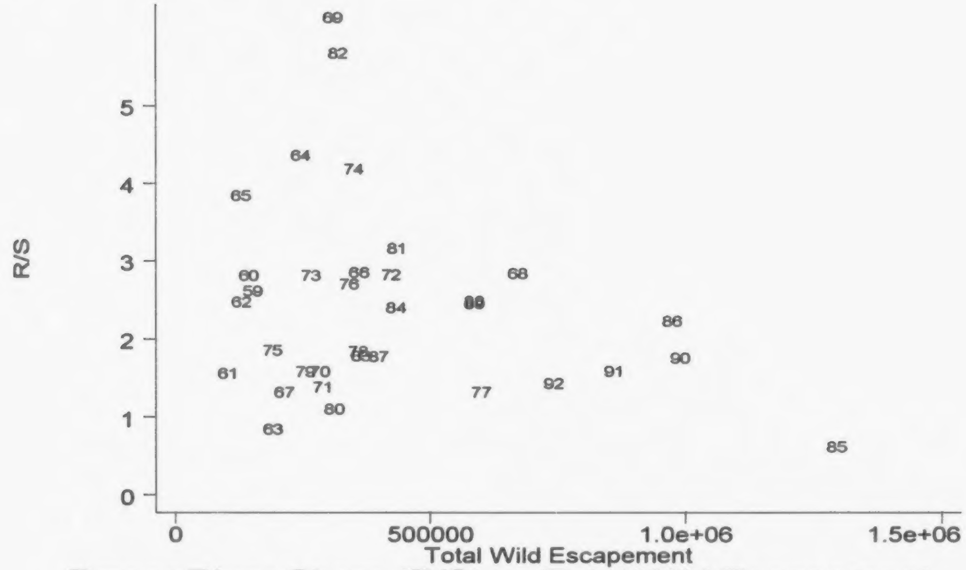


Figure 5.1



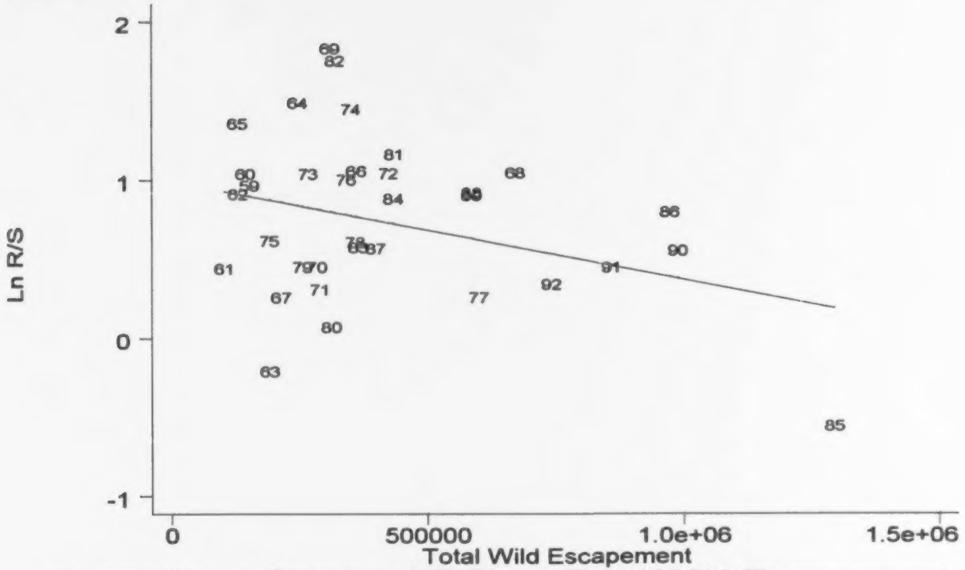
Fraser R. Chum Total Recruits vs Total Wild Escapement

Figure 5.2



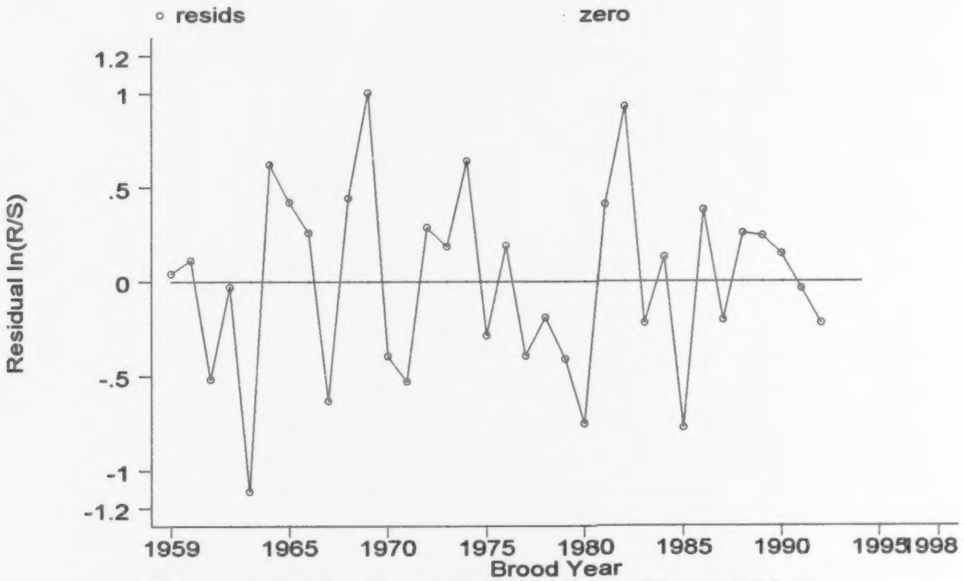
Fraser River Chum (R/S) vs Total Wild Escapement

Figure 5.3



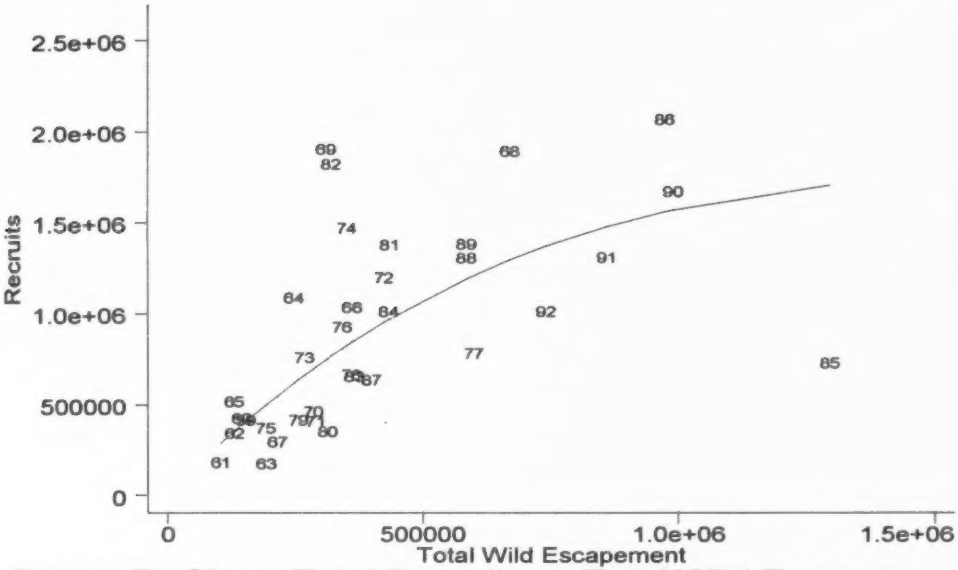
Fraser River Chum Ln(R/S) vs Total Wild Escapement

Figure 5.4



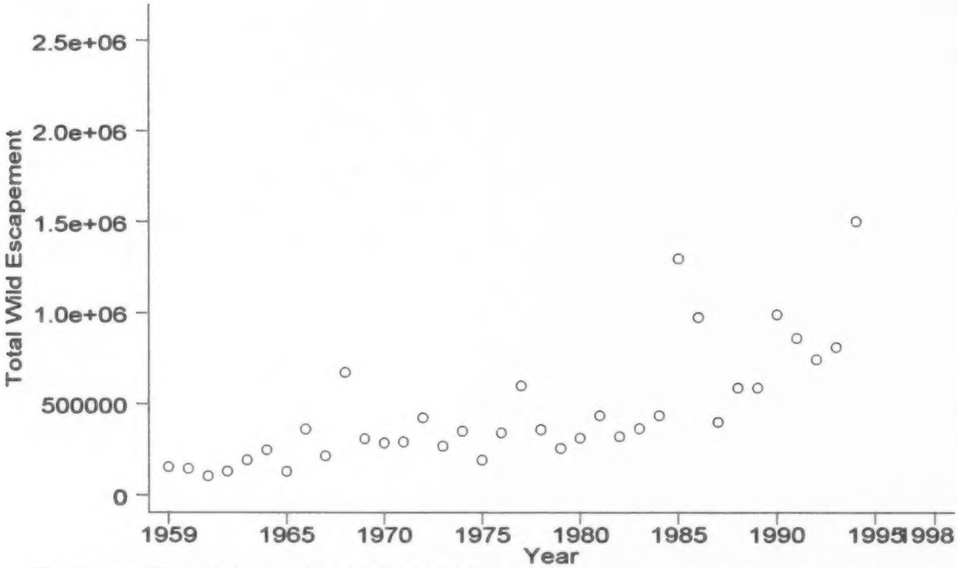
Fraser River Residual R/S vs Brood Year

Figure 5.5



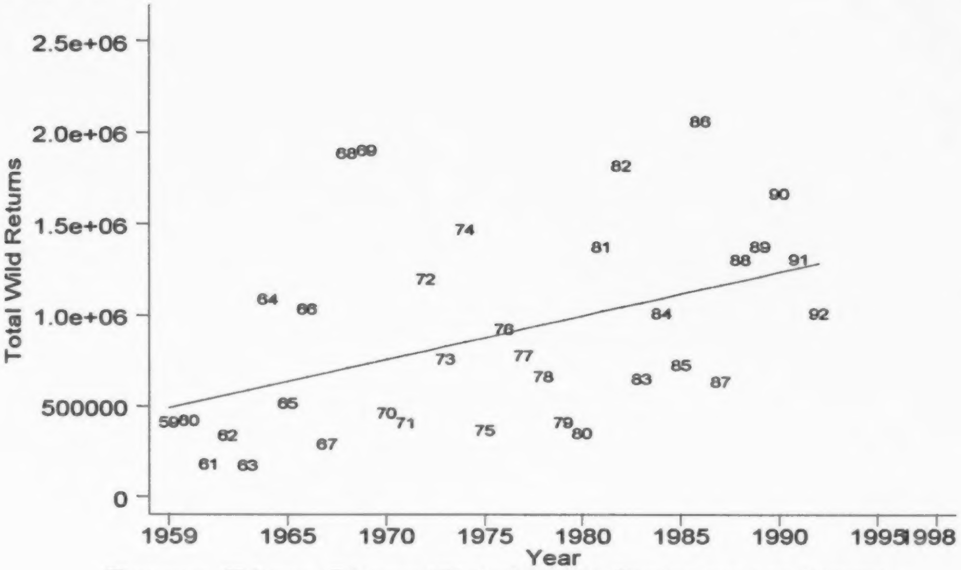
Fraser R. Chum Total Recruits vs Total Wild Escapement

Figure 5.6



Fraser R. Chum Total Wild Escapement vs Return Year

Figure 5.7



Fraser River Chum Total Wild Returns vs Year

Figure 5.8a

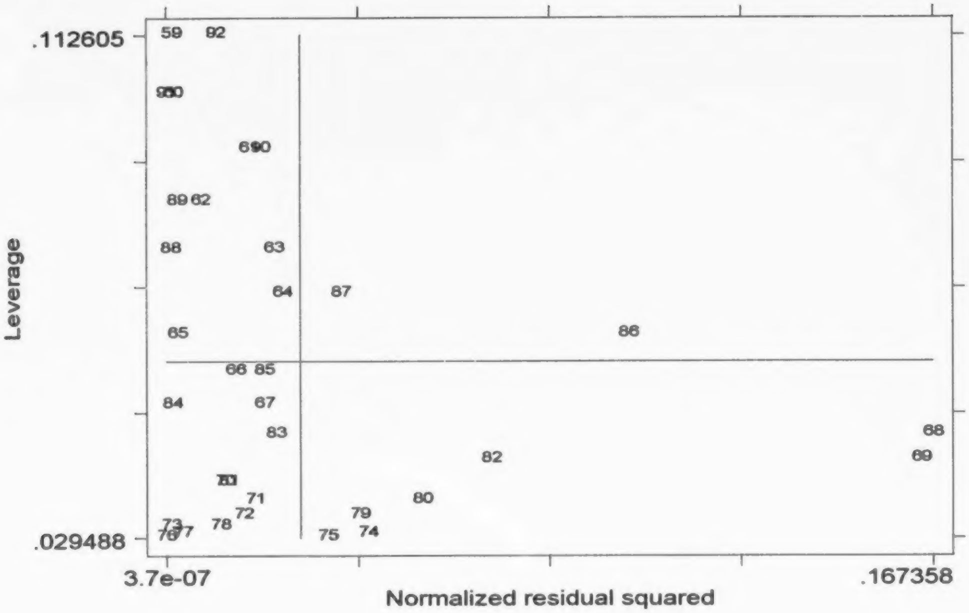


Figure 5.8b

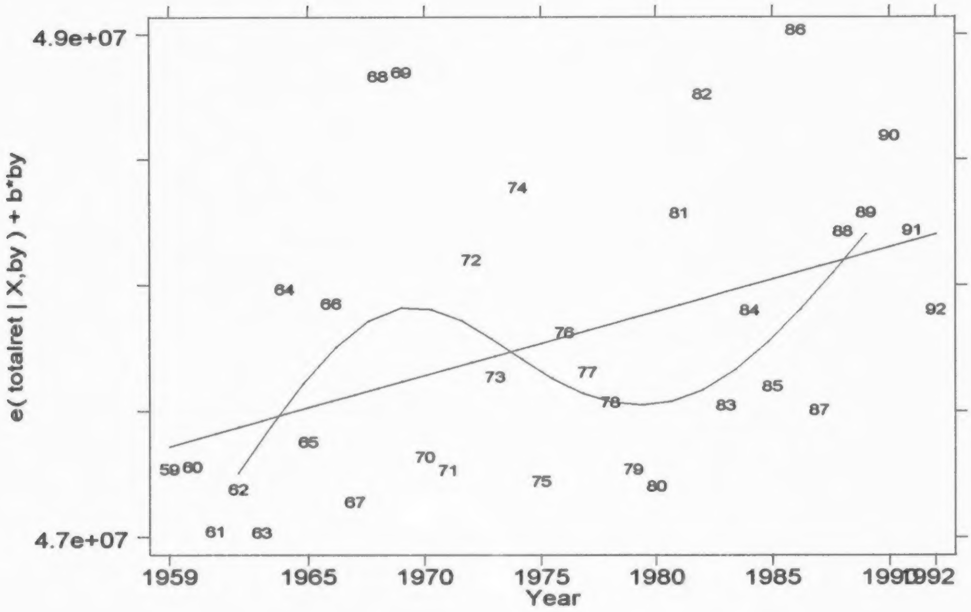
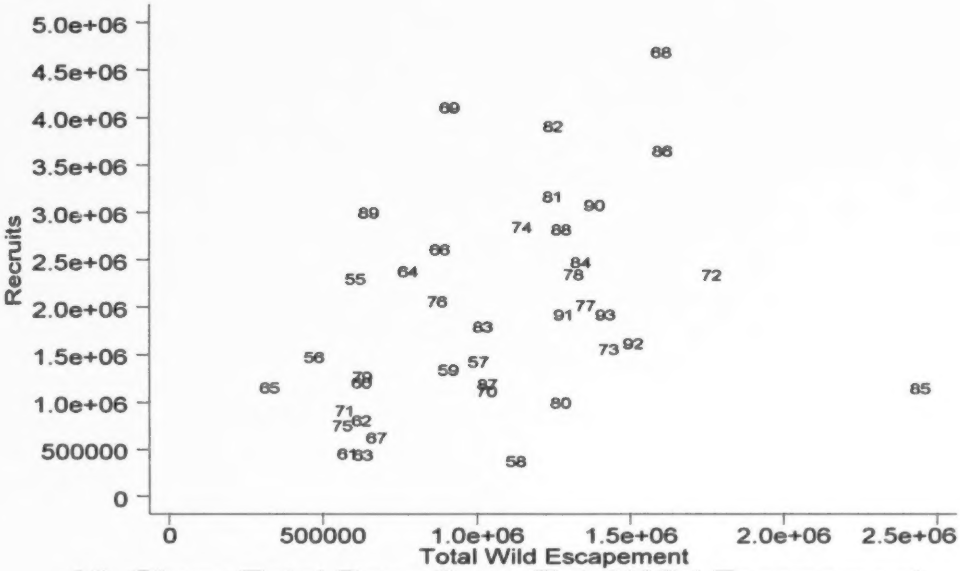
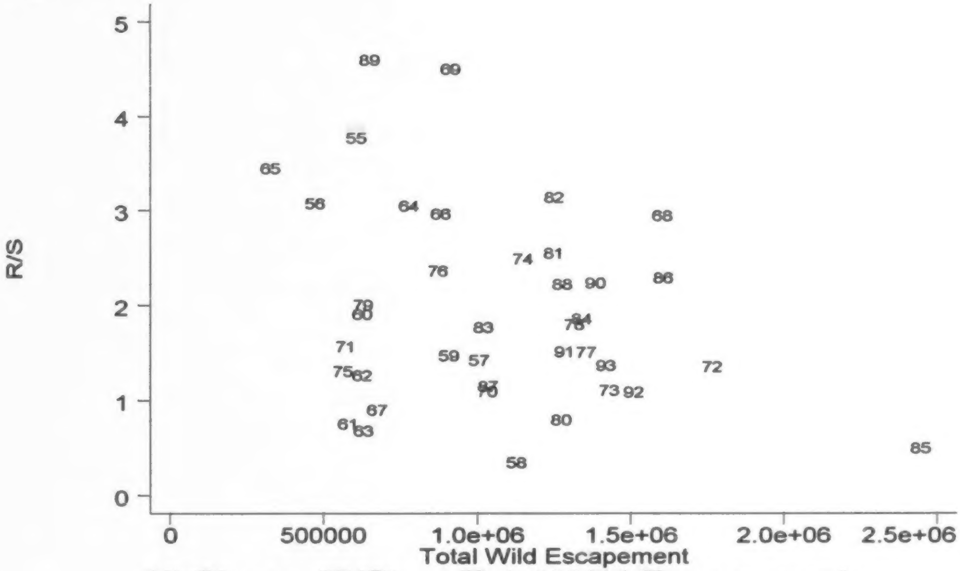


Figure 5.9



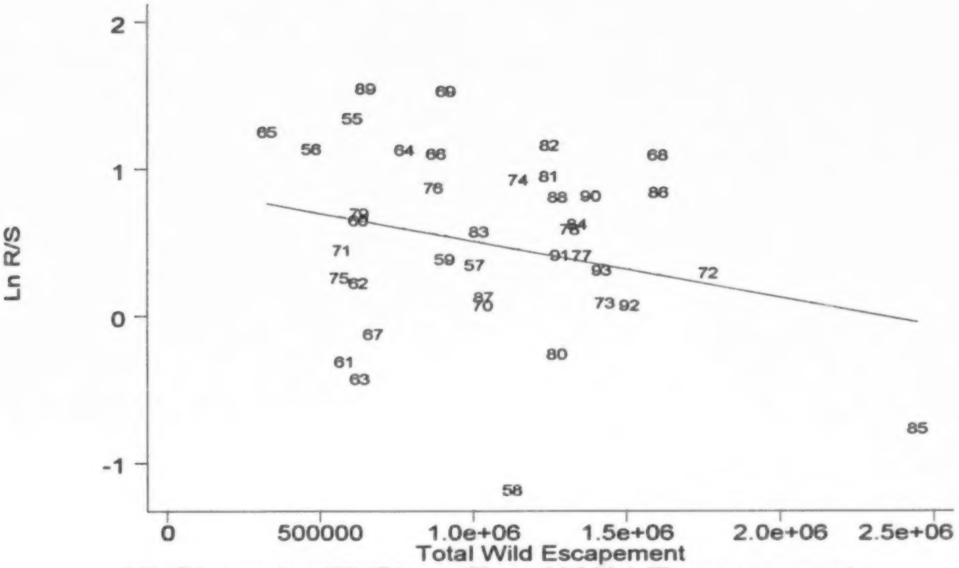
All Chum Total Recruits vs Total Wild Escapement

Figure 5.10



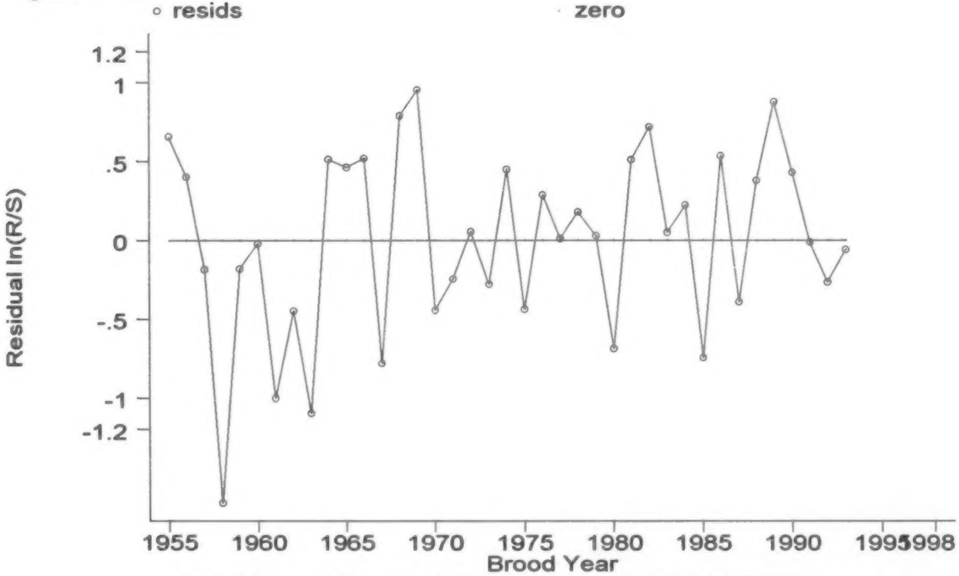
All Chum (R/S) vs Total Wild Escapement

Figure 5.11



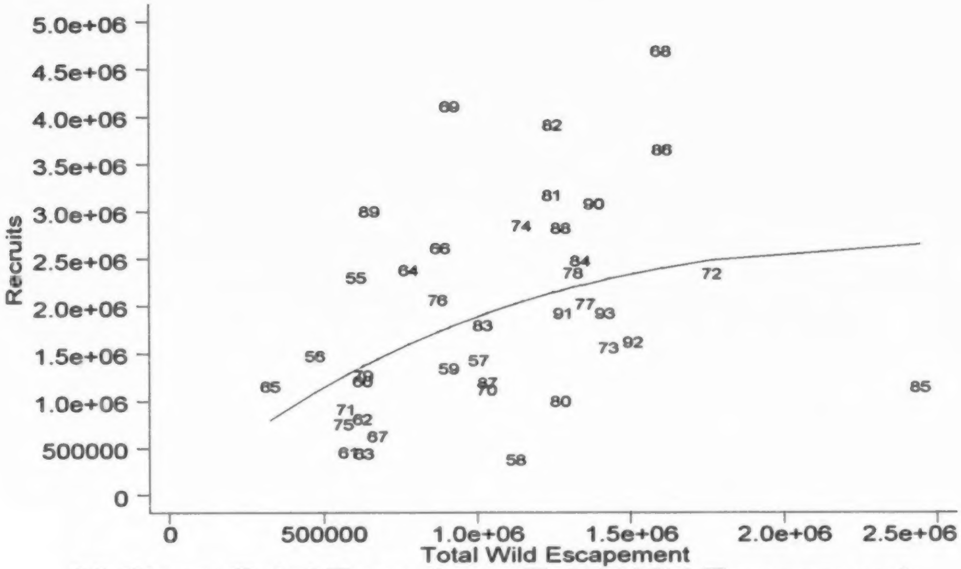
All Chum Ln(R/S) vs Total Wild Escapement

Figure 5.12



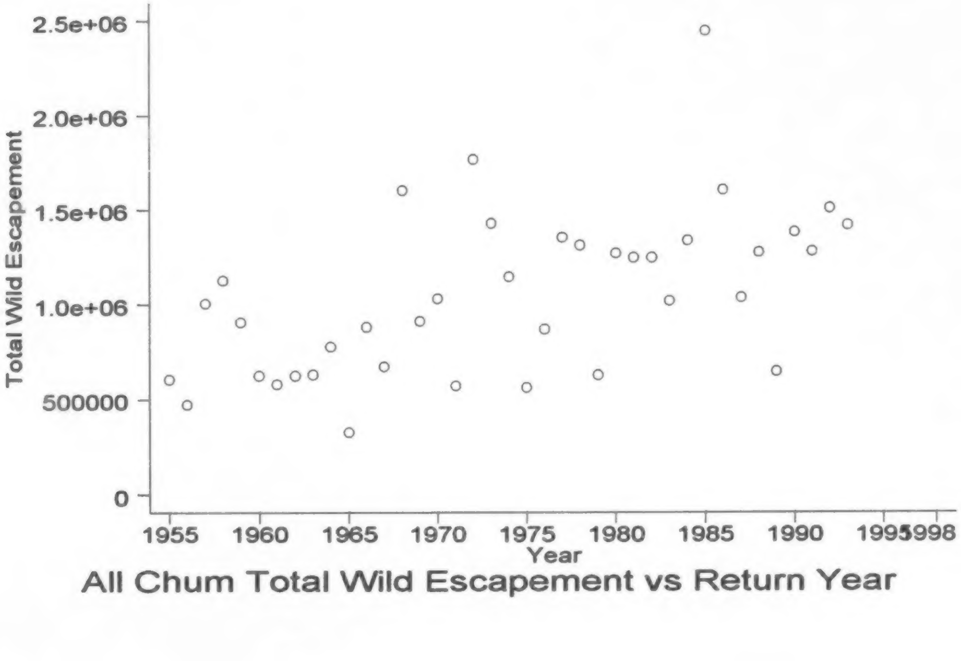
All Chum Residual R/S vs Brood Year

Figure 5.13



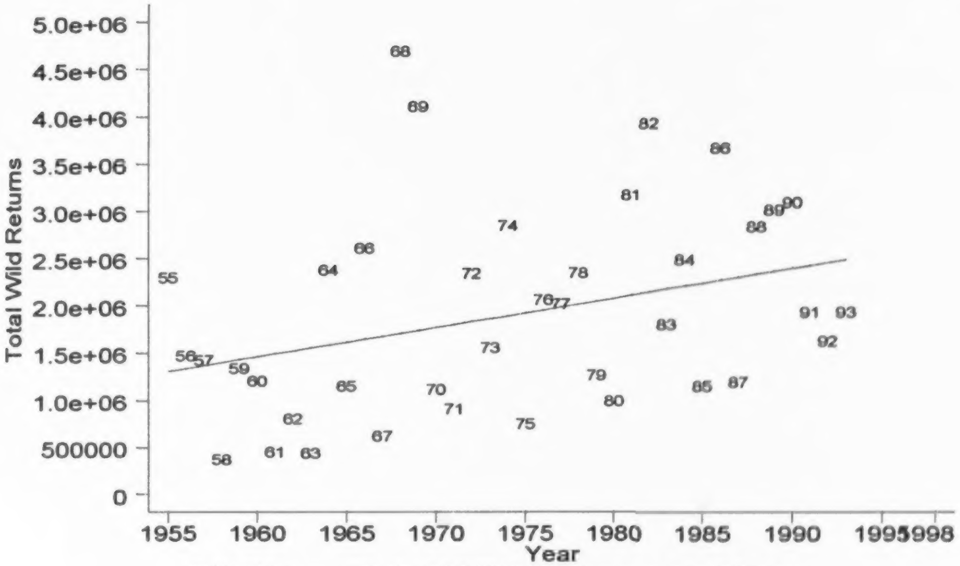
All Chum Total Recruits vs Total Wild Escapement

Figure 5.14



All Chum Total Wild Escapement vs Return Year

Figure 5.15



All Chum Total Wild Returns vs Year

Figure 5.16a

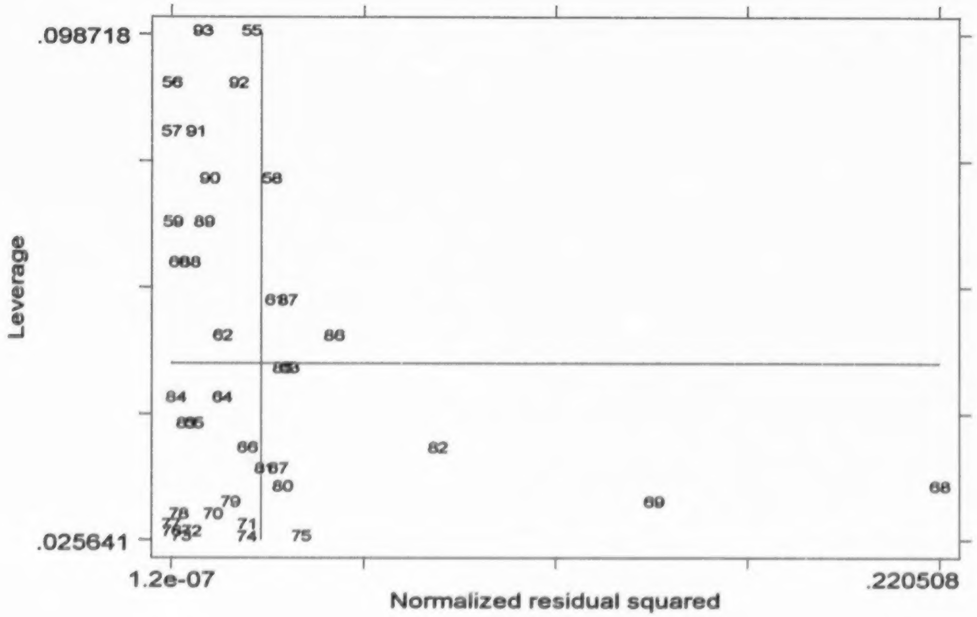


Figure 5.16b

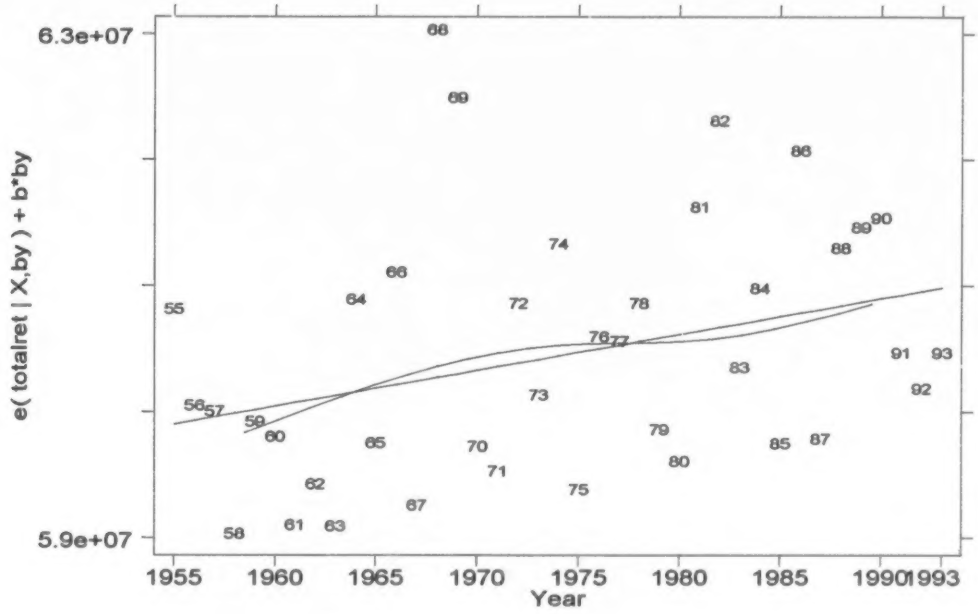


Figure 5.17. Trend in Clockwork chum exploitation rate from brood year 1953 to 1993.

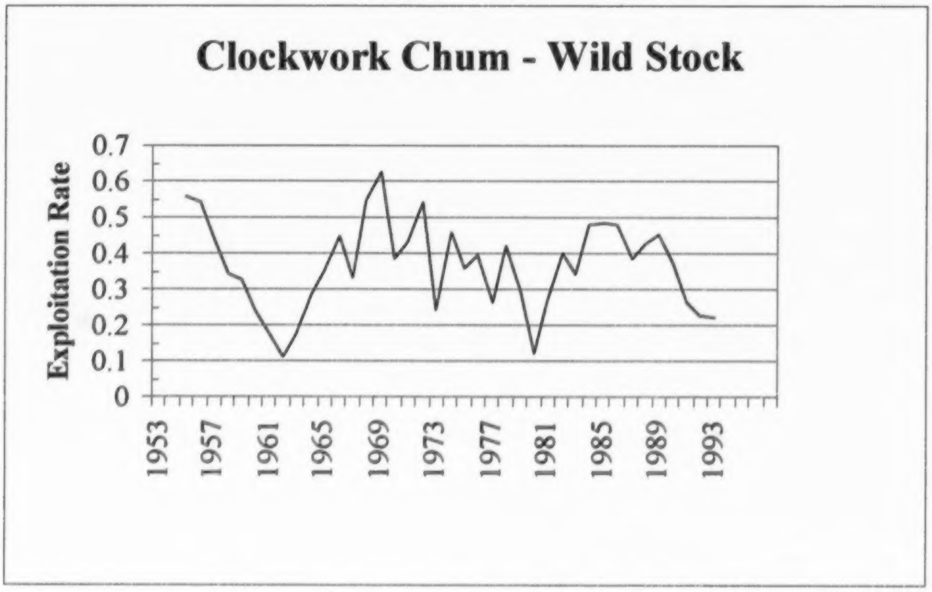
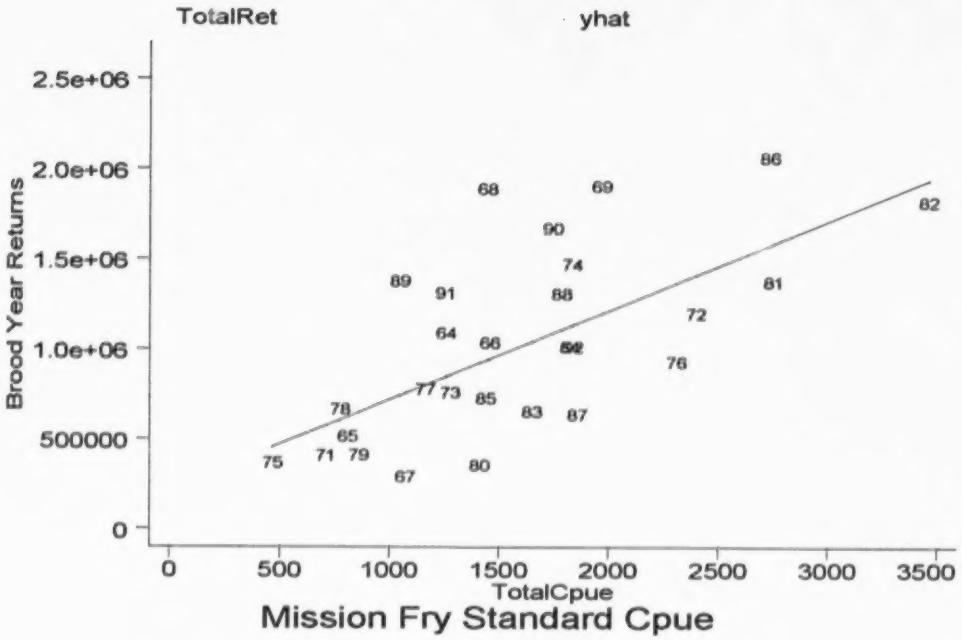


Figure 6 Relationship between an index of chum fry abundance migrating down the Fraser River measured at Mission, B.C. and brood year returns.



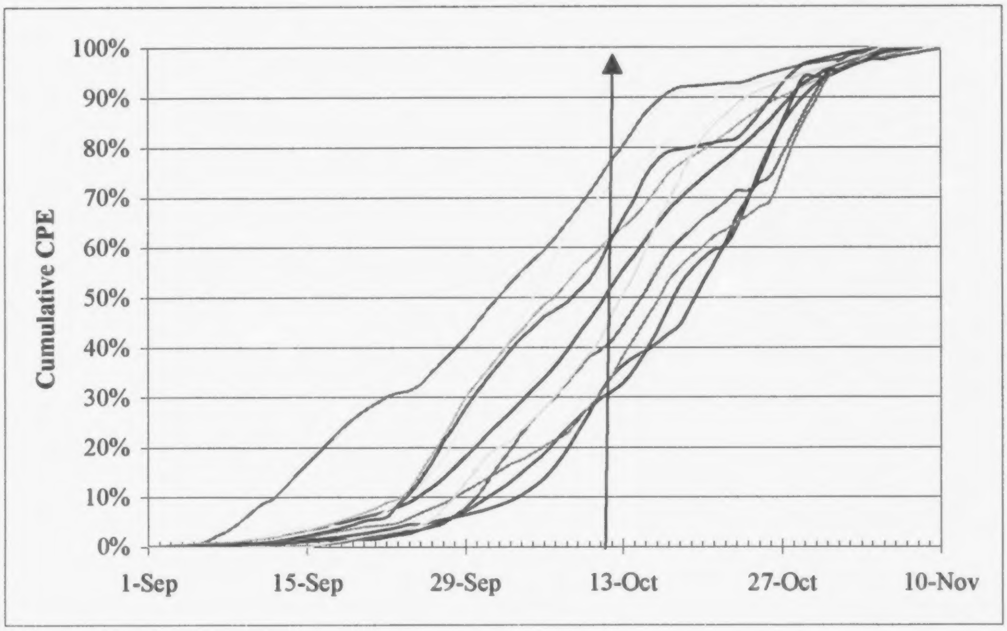


Figure 7.1. Clockwork chum salmon run timing past Johnstone Strait test fishery calculated from cumulative test fishing CPUE for years 1988 through 1997. The arrow marks the average 50% date.

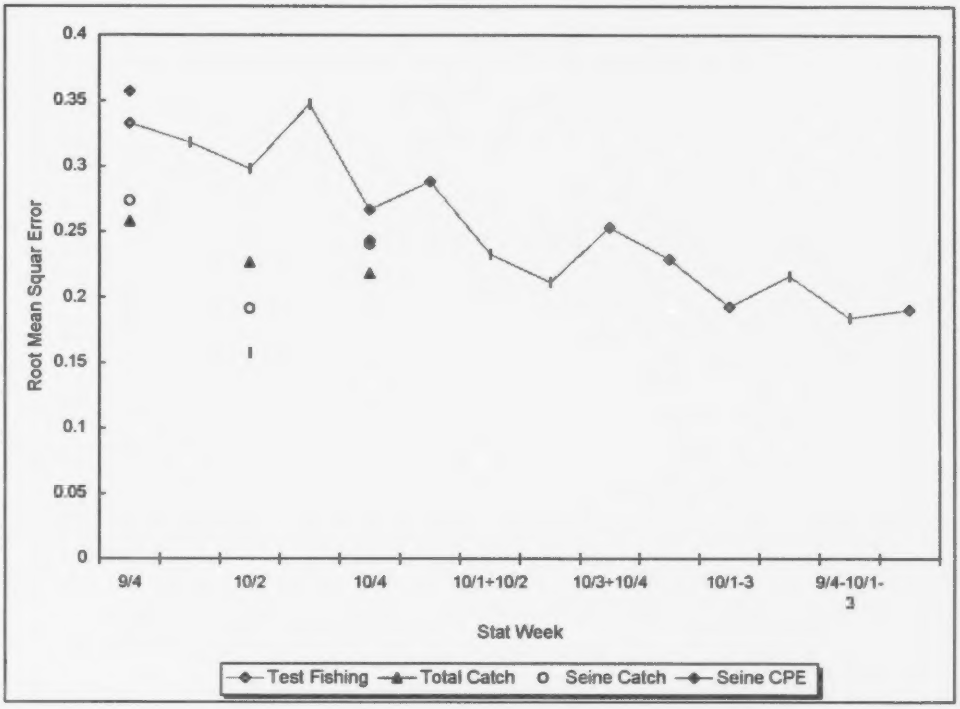


Figure 7.2 Residual mean square error associated with four models used to predict run size estimates in-season.

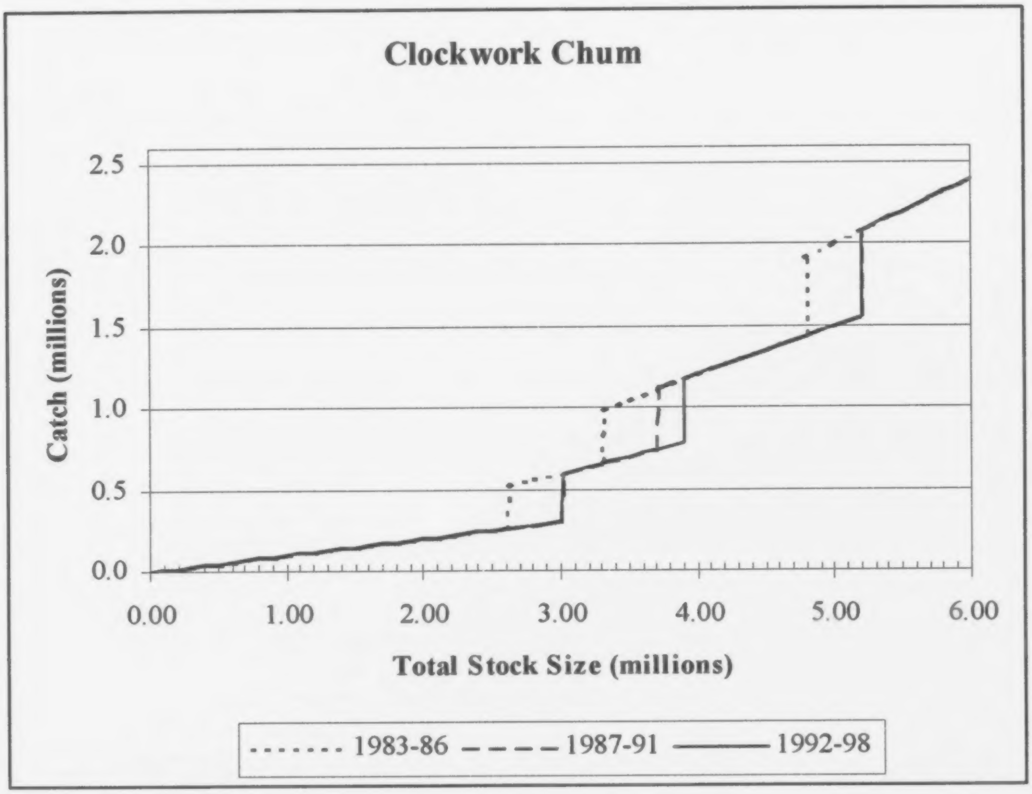


Fig. 8.1 Stepped harvest strategy in place for Clockwork chum.

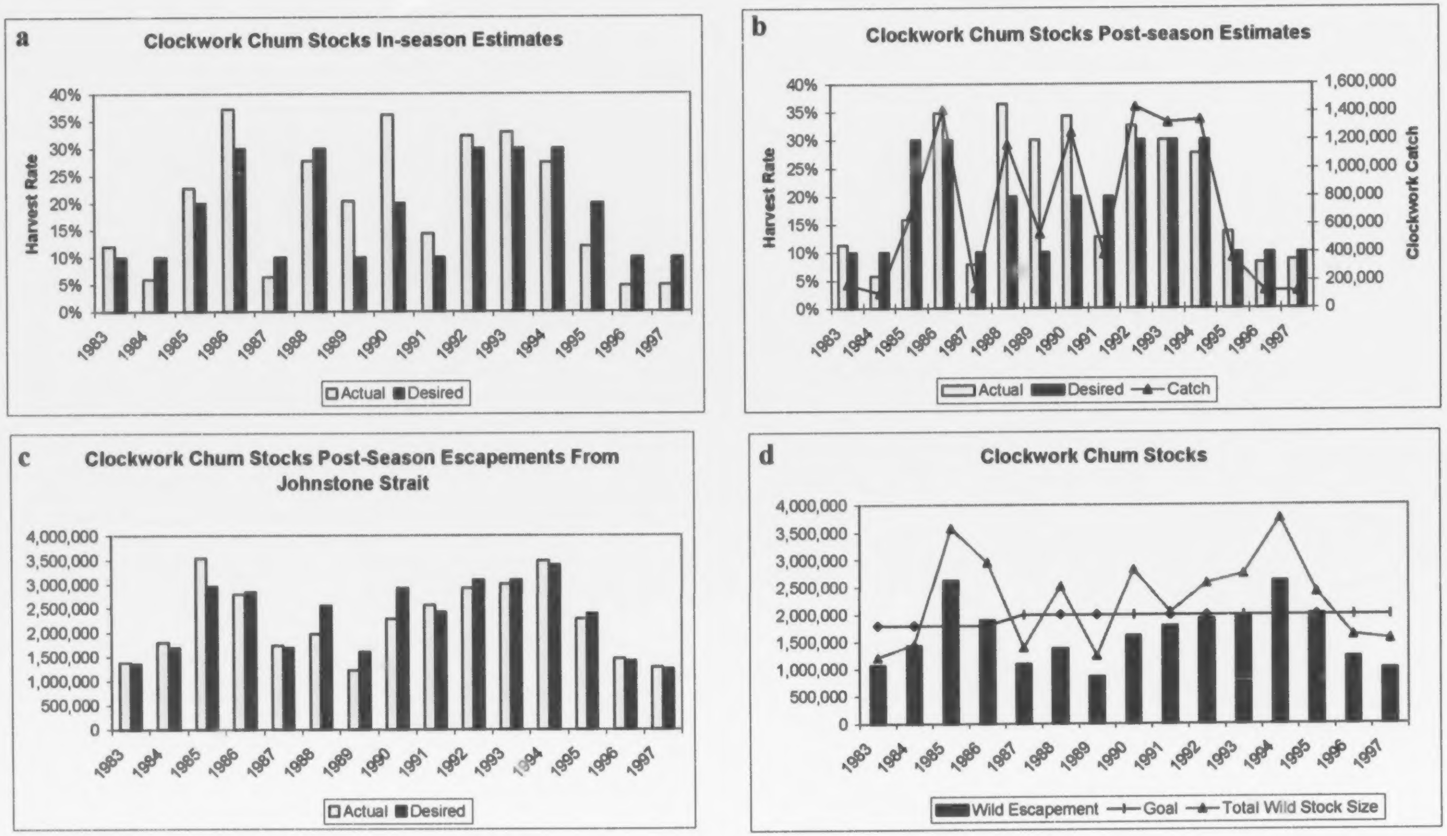


Fig. 8.2 Comparisons between actual and desired levels of harvest rate and escapement according to Clockwork management rules for the years 1983-97.

Figure 8.3. Data from 1968 to 1996

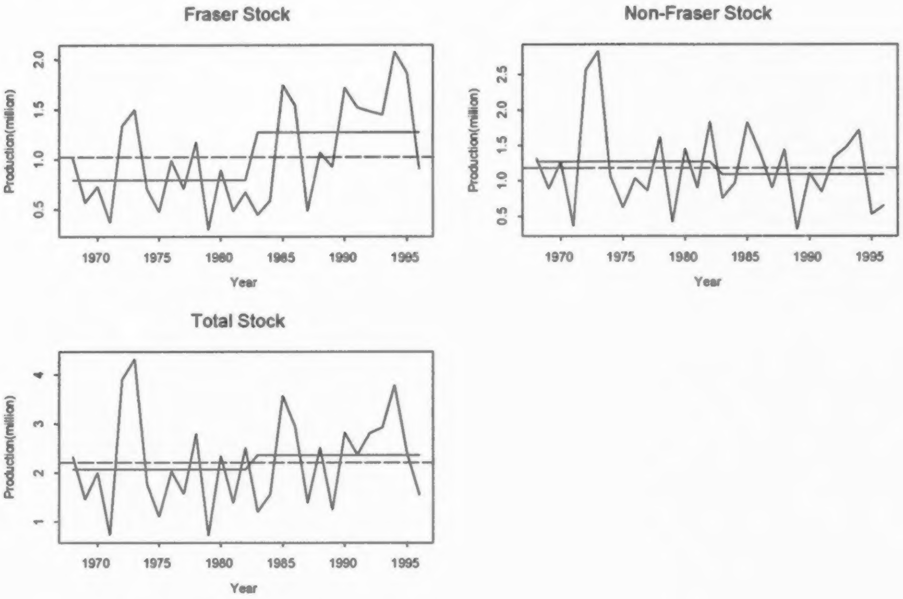


Figure 8.4. Data from 1974 to 1996

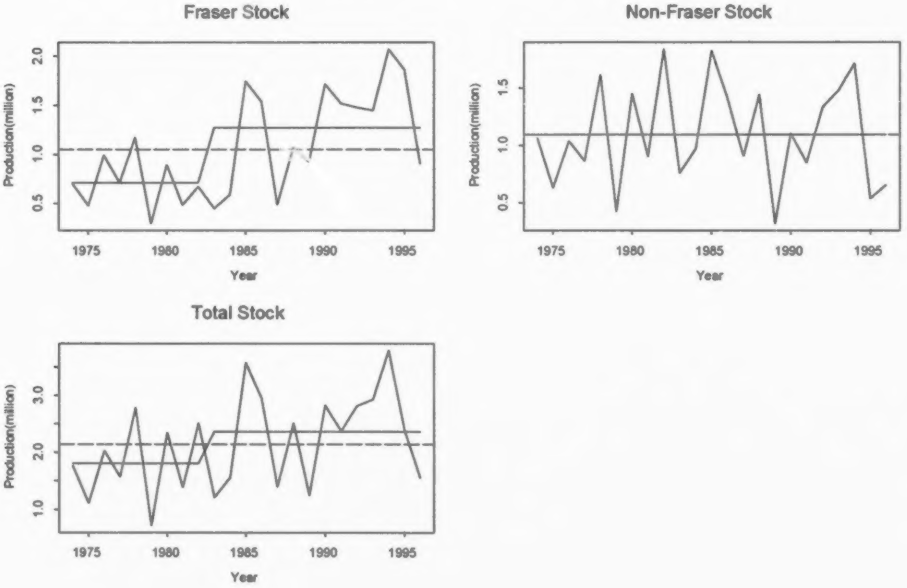


Table 3.1 Number of fed and unfed chum salmon fry released from SEP Operations major facilities (1978-1997 brood years)

NUMBER FRY RELEASED BY BROOD YEAR (MILLIONS)

HATCHERY	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
FED FRY RELEASES																
NON-FRASER																
PUNTLEDGE		1.5	3.3	2.4	7.4	6.5	7.4	5.1	4.9	4.1	3.2	2.8	5.2	5.2	4.9	3.8
BIG QUALICUM			2.6	2.2	2.6											
LITTLE QUALICUM			1.5	2.7	2.7	2.6	3.1	2.7	3.9							
NON-FRASER TOTAL		1.5	7.4	7.3	12.7	9.1	10.5	7.7	8.8	4.1	3.2	2.8	5.2	5.2	4.9	3.8
FRASER																
CHILLIWACK			0.8	3.9	4.2	1.2	3.4	4.1	4.5	2.8	2.6	3.1	3.0	3.0	3.0	2.5
INCH	0.9	1.1	0.9	1.3	2.5	2.3	2.3	1.8	1.1	1.0	1.1	1.2	0.7	0.9	1.0	1.1
STAVE					2.2	3.4	4.0	5.3	5.5	3.9	5.1	4.9	4.4	4.7	4.1	4.9
BLANEY	0.2	0.3	0.2	1.8	0.6	0.6	1.0	1.0	0.9							
CHEHALIS					8.3	13.6	14.0	17.0	13.5	12.3	14.2	11.0	12.8	12.4	10.4	10.9
FRASER TOTAL	1.1	1.4	2.0	7.0	17.7	21.1	24.8	29.2	25.4	19.9	23.0	20.2	20.9	20.9	18.5	19.5
FED TOTAL	1.1	2.8	9.4	14.3	30.4	30.2	35.3	36.9	34.2	24.0	26.2	23.1	26.1	26.1	23.4	23.2
% Change from previous year		152.4%	234.4%	51.5%	112.4%	-0.7%	16.8%	4.7%	-7.4%	-29.8%	9.3%	-12.0%	13.2%	0.1%	-10.4%	-0.7%
UNFED FRY RELEASES																
NON-FRASER																
PUNTLEDGE								0.4								
BIG QUALICUM	45.5	57.8	60.7	43.7	58.9	58.2	24.0	26.0	48.1	56.6	66.0	47.1	45.5	35.6	66.8	63.5
LITTLE QUALICUM		6.1	6.1	1.4	22.8	18.9	21.2	6.9	40.1	39.4	37.5	28.0	42.7	32.1	42.5	30.6
NON-FRASER TOTAL	45.5	63.9	66.9	45.1	81.8	77.1	45.2	33.3	88.2	96.0	103.5	75.1	88.2	67.7	109.3	94.1
FRASER																
INCH													0.1	0.1		
CHILLIWACK												1.9	2.4	2.4	0.9	1.3
FRASER TOTAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	2.5	2.5	0.9	1.3
UNFED TOTAL	45.5	63.9	66.9	45.1	81.8	77.1	45.2	33.3	88.2	96.0	103.5	77.0	90.7	70.1	110.2	95.4
% Change		40.4%	4.7%	-32.6%	81.4%	-5.7%	-41.4%	-26.4%	165.1%	8.8%	7.8%	-25.6%	17.8%	-22.6%	57.2%	-13.5%

Table 3.1 (con't). Number of fed and unfed chum salmon fry released from SEP Operations major facilities (1978-1997 brood year

	NUMBER FRY RELEASED BY BROOD YEAR (MILLIONS)								
					ORIGINAL	CURRENT	MEAN	MEAN	MEAN
HATCHERY	1994	1995	1996	1997	TARGET	TARGET	78-81	82-86	87-97
	FED FRY RELEASES								
NON-FRASER									
PUNTLEDGE	5.0	4.4	3.9	5.8	5.0	3.8	1.8	6.3	4.4
BIG QUALICUM			1.6	1.3			1.2	0.5	0.3
LITTLE QUALICUM			2.1				1.1	3.0	0.2
NON-FRASER TOTAL	5.0	4.4	7.5	7.1	5.0	3.8	4.0	9.7	4.8
FRASER									
CHILLIWACK	3.1	3.1	2.5	2.9	3.5	3.0	1.2	3.5	2.9
INCH	1.1	1.2	1.1	1.2	1.5	1.0	1.1	2.0	1.1
STAVE	4.8	4.6	3.1	2.1	4.6	0.0	0.0	4.1	4.2
BLANEY					0.6	-	0.6	0.8	0.0
CHEHALIS	8.9	11.0	9.2	8.8	13.6	7.8	0.0	13.3	11.1
FRASER TOTAL	17.9	19.8	15.9	15.0	23.8	11.8	2.9	23.6	19.2
FED TOTAL	22.9	24.2	23.4	22.0	28.8	15.6	6.9	33.4	24.1
% Change	-1.4%	5.8%	-3.4%	-5.9%		-46.0%		382.1%	-27.9%
	UNFED FRY RELEASES								
NON-FRASER									
PUNTLEDGE		0.2					0.0	0.1	0.0
BIG QUALICUM	46.0	17.1	6.7	30.2	53.6	45.0	51.9	43.0	43.7
LITTLE QUALICUM	31.9	11.0	6.8	9.4	34.6	38.0	3.4	22.0	28.4
NON-FRASER TOTAL	78.0	28.4	13.6	39.6	88.2	83.0	55.3	65.1	72.1
FRASER									
INCH	0.0						0.0	0.0	0.0
CHILLIWACK	1.7	1.7		0.5	0.4	1.9	0.0	0.0	1.2
FRASER TOTAL	1.7	1.7	0.0	0.5	0.4	1.9	0.0	0.0	1.2
UNFED TOTAL	79.7	30.1	13.6	40.1	88.6	84.9	55.3	65.1	73.3
% Change	-16.5%	-62.3%	-54.8%	195.1%		-4.2%		17.7%	12.6%

Table 3.2.1 ISC enhanced facilities contribution to commercial net catch (does not include non-sampled strata including U.S., troll, sport, or native catches)

Rtn Yr	Puntledge	Big Qualicum	L.Qualicum	Chilliwack	Chehalis	Blaney	Inch	Stave	Total	Inside	Fraser
1980		98,783				687	2,069		101,539	98,783	2,756
1981		46,206				274	33		46,513	46,206	307
1982	4,750	207,514	2,823			669	1,556		217,312	215,087	2,225
1983	7,259	100,422	3,905	0		61	0		111,647	111,586	61
1984	16,767	149,880	10,642	1,694		0	1,999		180,982	177,289	3,693
1985	56,261	408,946	120,036	12,434	9,598	1,139	2,209	2,396	613,019	585,243	27,776
1986	87,540	333,338	164,032	49,785	55,922	2,863	2,112	14,321	709,913	584,910	125,003
1987	73,540	142,512	59,859	2,504	2,949	132	1,702	614	283,812	275,911	7,901
1988	17,232	119,042	59,821	54,791	81,472	12,275	8,349	51,371	404,353	196,095	208,258
1989	11,004	91,454	41,327	10,606	57,235	1,570	2,585	18,571	234,352	143,785	90,567
1990	33,013	200,952	77,058	26,543	64,536	1,848	3,718	48,431	456,099	311,023	145,076
1991	60,578	178,972	36,025	9,201	17,217	0	1,653	7,658	311,304	275,575	35,729
1992	27,367	837,952	183,129	32,600	50,878	0	4,741	40,044	1,176,711	1,048,448	128,263
1993	57,477	557,149	141,664	38,422	48,772		6,700	41,750	891,934	756,290	135,644
1994	39,263	356,921	154,484	31,601	53,446		4,027	29,981	669,723	550,668	119,055
1995	4,588	24,887	6,896	7,072	16,528		2,339	7,562	69,873	36,371	33,502
1996	0	1,662	505	2,290	0		0	213	4,670	2,168	2,503
1997*	816	2,939	893	3,501	638		0	945	9,732	4,648	5,084

*Data for 1997 is preliminary.

Total											
80-84	28,776	602,805	17,370	1,694		1,691	5,657		657,993	648,951	9,042
85-89	245,577	1,095,292	445,075	130,120	207,176	17,979	16,957	87,273	2,245,449	1,785,944	459,505
90-94	217,698	2,131,946	592,360	138,367	234,849	1,848	20,839	167,864	3,505,771	2,942,004	563,767
95-97	5,404	29,488	8,294	12,863	17,166		2,339	8,720	84,275	43,187	41,088
85-94	463,275	3,227,238	1,037,435	268,487	442,025	19,827	37,796	255,137	5,751,220	4,727,948	1,023,272
85-97	468,679	3,256,726	1,045,729	281,350	459,191	19,827	40,135	263,857	5,835,495	4,771,135	1,064,360
All	497,455	3,859,531	1,063,099	283,044	459,191	21,518	45,792	263,857	6,493,488	5,420,086	1,073,402

Annual Mean											
80-84	9,592	120,561	5,790	847		338	1,131		131,599	129,790	1,808
85-89	49,115	219,058	89,015	26,024	41,435	3,596	3,391	17,455	449,090	357,189	91,901
90-94	43,540	426,389	118,472	27,673	46,970	616	4,168	33,573	701,154	588,401	112,753
95-97	1,801	9,829	2,765	4,288	5,722		780	2,907	28,092	14,396	13,696
85-94	46,328	322,724	103,744	26,849	44,203	2,478	3,780	25,514	575,122	472,795	102,327
85-97	36,052	250,517	80,441	21,642	35,322	2,478	3,087	20,297	448,884	367,010	81,874
All	31,091	214,418	66,444	18,870	35,322	1,655	2,544	20,297	360,749	301,116	59,633

Table 3.2.2 Inner South Coast enhanced facilities contribution to escapement.

Rtn Yr.	Puntledge	Big Qualicum	L.Qualicum	Chilliwack	Chehalis	Blaney	Inch	Stave	Total	Inside	Fraser
1980		97,575				622	1,870		100,067	97,575	2,492
1981		88,831				3,482	1,702		94,015	88,831	5,184
1982	3,189	139,344	12,272			696	6,158		161,659	154,805	6,854
1983	10,566	145,648	24,121	174		448	5,262		186,219	180,335	5,884
1984	17,706	100,220	25,558	4,322		2,992	2,374		153,172	143,484	9,688
1985	24,529	188,583	60,907	44,076	42,456	9,936	14,459	46,099	431,045	274,019	157,026
1986	43,019	167,302	78,940	35,635	119,115	5,593	10,288	48,809	508,701	289,261	219,440
1987	37,431	76,422	28,901	23,848	37,324	179	15,783	4,840	224,728	142,754	81,974
1988	10,488	86,615	39,411	22,201	73,913	3,575	9,161	55,402	300,766	136,514	164,252
1989	9,541	61,243	34,741	21,033	128,244	4,676	1,403	70,093	330,974	105,525	225,449
1990	32,455	66,464	52,810	13,989	128,576	1,429	2,616	63,678	362,017	151,729	210,288
1991	6,322	83,320	67,248	28,971	101,113	0	5,601	51,193	343,768	156,890	186,878
1992	22,475	123,478	55,435	27,633	64,389		11,116	78,830	383,356	201,388	181,968
1993	8,488	204,888	104,030	98,428	45,207		7,225	120,819	589,085	317,406	271,679
1994	30,347	146,693	134,316	70,445	48,951		14,644	39,711	485,107	311,356	173,751
1995	17,797	57,531	29,707	31,222	42,268		6,341	21,193	206,058	105,035	101,023
1996	6,785	45,696	15,985	28,712	52,829		5,533	47,819	203,358	68,466	134,892
1997*	24,064	86,673	31,552	34,721	78,741		38,313	16,244	310,309	142,289	168,020

*Data for 1997 is preliminary. Puntledge 1997 escapement is estimated from Big Qualicum exploitation rate.

Total											
80-84	31,461	571,618	61,951	4,496		8,240	17,366		695,132	665,030	30,102
85-89	125,008	580,165	242,900	146,793	401,052	23,959	51,094	225,243	1,796,214	948,073	848,141
90-94	100,087	624,843	413,839	239,466	388,236	1,429	41,202	354,231	2,163,333	1,138,769	1,024,564
95-97	48,646	189,900	77,244	94,655	173,838		50,187	85,256	719,726	315,790	403,935
85-94	225,095	1,205,008	656,739	386,259	789,288	25,388	92,296	579,474	3,959,547	2,086,842	1,872,705
85-97	273,741	1,394,908	733,983	480,914	963,126	25,388	142,483	664,730	4,679,273	2,402,632	2,276,640
All	305,202	1,966,526	795,934	485,410	963,126	33,628	159,849	664,730	5,374,405	3,067,662	2,306,742
Annual Mean											
80-84	10,487	114,324	20,650	2,248		1,648	3,473		139,026	133,006	6,020
85-89	25,002	116,033	48,580	29,359	80,210	4,792	10,219	45,049	359,243	189,615	169,628
90-94	20,017	124,969	82,768	47,893	77,647	715	8,240	70,846	432,667	227,754	204,913
95-97	16,215	63,300	25,748	31,552	57,946		16,729	28,419	239,909	105,263	134,645
85-94	22,510	120,501	65,674	38,626	78,929	3,627	9,230	57,947	395,955	208,684	187,271
85-97	21,057	107,301	56,460	36,993	74,087	3,627	10,960	51,133	359,944	184,818	175,126
All	19,075	109,251	49,746	32,361	74,087	2,802	8,880	51,133	298,578	170,426	128,152

Table 3.2.3 Inner South Coast enhanced facilities contribution to commercial net catch + escapement (does not include non-sampled strata including U.S., troll, sport, or native catches)

Rtn Yr	Puntledge	Big Qualicum	L Qualicum	Chilliwack	Chehalis	Blaney	Inch	Stave	Total	Inside	Fraser
1980		196,358				1,309	3,939		201,606	196,358	5,248
1981		135,037				3,756	1,735		140,528	135,037	5,491
1982	7,939	346,858	15,095	0		1,365	7,714		378,971	369,892	9,079
1983	17,825	246,070	28,026	174		509	5,262		297,866	291,921	5,945
1984	34,473	250,100	36,200	6,016		2,992	4,373		334,154	320,773	13,381
1985	80,790	597,529	180,943	56,510	52,054	11,075	16,668	48,495	1,044,064	859,262	184,802
1986	130,559	500,640	242,972	85,420	175,037	8,456	12,400	63,130	1,218,614	874,171	344,443
1987	110,971	218,934	88,760	26,352	40,273	311	17,485	5,454	508,540	418,665	89,875
1988	27,720	205,657	99,232	76,992	155,385	15,850	17,510	106,773	705,119	332,609	372,510
1989	20,545	152,697	76,068	31,639	185,479	6,246	3,988	88,664	565,326	249,310	316,016
1990	65,468	267,416	129,868	40,532	193,112	3,277	6,334	112,109	818,116	462,752	355,364
1991	66,900	262,292	103,273	38,172	118,330	0	7,254	58,851	655,072	432,465	222,607
1992	49,842	961,430	238,564	60,233	115,267		15,857	118,874	1,560,067	1,249,836	310,231
1993	65,965	762,037	245,694	136,850	93,979		13,925	162,569	1,481,019	1,073,696	407,323
1994	69,610	503,614	288,800	102,046	102,397		18,671	69,692	1,154,830	862,024	292,806
1995	22,385	82,418	36,603	38,294	58,796		8,680	28,755	275,930	141,406	134,524
1996	6,785	47,359	16,490	31,001	52,829		5,533	48,032	208,029	70,634	137,395
1997*	24,880	89,612	32,445	38,222	79,379		38,313	17,189	320,041	146,937	173,104

*Data for 1997 is preliminary. Puntledge 1997 escapement is estimated from Big Qualicum exploitation rate.

Total

80-84	60,237	1,174,423	79,321	6,190		9,931	23,023		1,353,125	1,313,981	39,144
85-89	370,585	1,675,457	687,975	276,913	608,228	41,938	68,051	312,516	4,041,663	2,734,017	1,307,646
90-94	317,785	2,756,789	1,006,199	377,833	623,085	3,277	62,041	522,095	5,669,104	4,080,773	1,588,331
95-97	54,050	219,389	85,538	107,518	191,004		52,526	93,976	804,000	358,977	445,023
85-94	688,370	4,432,246	1,694,174	654,746	1,231,313	45,215	130,092	834,611	9,710,767	6,814,790	2,895,977
85-97	742,420	4,651,635	1,779,712	762,264	1,422,317	45,215	182,618	928,587	10,514,767	7,173,767	3,341,000
All	802,657	5,826,058	1,859,033	768,454	1,422,317	55,146	205,641	928,587	11,867,892	8,487,748	3,380,144

Annual Mean

80-84	20,079	234,885	26,440	2,063		1,986	4,605		270,625	262,796	7,829
85-89	74,117	335,091	137,595	55,383	121,646	8,388	13,610	62,503	808,333	546,803	261,529
90-94	63,557	551,358	201,240	75,567	124,617	1,639	12,408	104,419	1,133,821	816,155	317,666
95-97	18,017	73,130	28,513	35,839	63,668		17,509	31,325	268,000	119,659	148,341
85-94	68,837	443,225	169,417	65,475	123,131	6,459	13,009	83,461	971,077	681,479	289,598
85-97	57,109	357,818	136,901	58,636	109,409	6,459	14,048	71,430	808,828	551,828	257,000
All	50,166	323,670	116,190	48,028	109,409	4,596	11,425	71,430	659,327	471,542	187,786

Table 3.2.4 Inner South Coast enhanced chum contribution as a percent of enhanced + wild chum catch and escapement (does not include non-sampled strata including U.S., troll, sport, or native catches)

	Inside			Fraser			Total		
Rtn.Yr.	Catch	Esc	Total	Catch	Esc	Total	Catch	Esc	Total
1962	3.6	7.5	6.4				2.7	6.0	5.1
1963	13.2	7.9	9.6				9.3	5.6	6.8
1964	5.3	6.4	6.3				3.3	4.5	4.3
1965	1.0	8.7	7.8				1.1	5.5	5.2
1966	0.3	9.4	8.7				0.4	5.8	5.5
1967	6.5	8.6	8.2				5.5	6.0	5.9
1968	7.3	13.1	11.5				4.8	8.1	7.2
1969	27.1	14.3	18.9				18.0	10.0	12.9
1970	14.8	15.1	15.0				9.5	11.4	10.5
1971	5.8	27.3	23.2				4.7	15.6	14.1
1972	11.8	5.4	8.6				8.6	4.2	6.4
1973	14.8	12.2	13.7				10.2	10.2	10.2
1974	3.0	10.4	8.6				2.3	7.5	6.3
1975	15.5	22.8	20.0				10.3	16.3	13.9
1976	15.2	15.8	15.5				9.9	10.3	10.1
1977	5.9	12.1	11.3				5.3	7.1	7.0
1978	29.5	11.5	19.9				20.0	8.7	14.2
1979	10.3	26.7	25.0				10.1	17.7	17.2
1980	16.6	9.2	11.9	1.1	0.8	0.9	12.3	7.3	9.2
1981	33.4	9.8	12.9	0.9	1.2	1.2	38.6	7.0	9.6
1982	19.1	14.2	16.7	0.9	2.1	1.6	15.7	11.5	13.6
1983	50.8	21.5	27.6	0.1	1.6	1.4	48.0	15.5	20.7
1984	71.9	13.6	24.6	7.7	1.8	2.3	88.6	9.6	18.5
1985	45.4	17.3	29.9	10.2	12.1	11.8	56.1	15.0	26.3
1986	39.3	25.4	33.3	31.2	22.6	25.1	44.4	24.1	32.8
1987	50.0	16.6	29.6	13.7	20.6	19.7	63.7	17.8	29.9
1988	17.1	13.8	15.6	69.9	28.1	42.3	31.9	19.1	24.8
1989	29.6	26.7	28.3	35.7	38.5	37.6	40.5	33.8	36.3
1990	26.9	20.1	24.2	31.2	21.3	24.5	31.3	20.7	25.6
1991	38.1	20.5	29.3	26.0	15.7	16.9	43.9	17.6	24.9
1992	60.3	17.5	43.4	36.3	18.6	23.4	61.0	18.0	38.6
1993	43.0	26.5	36.4	50.7	27.4	32.5	47.8	26.9	36.6
1994	34.7	24.2	30.0	33.9	11.4	15.7	38.1	17.3	25.3
1995	10.0	26.9	17.9	36.0	6.0	7.8	22.5	10.0	11.9
1996	0.7	15.4	9.5	15.6	15.5	15.6	4.6	12.6	12.1
1997	1.3	29.3	17.4	14.0	25.6	25.0	4.8	15.2	14.3
Annual Mean									
80-84	38.4	13.6	18.7	2.1	1.5	1.5	40.7	10.2	14.3
85-89	36.3	19.9	27.4	32.1	24.4	27.3	47.3	21.9	30.0
90-94	40.6	21.7	32.7	35.6	18.9	22.6	44.4	20.1	30.2
95-97	4.0	23.9	15.0	21.9	15.7	16.1	10.7	12.6	12.8
85-94	38.4	20.8	30.0	33.9	21.6	24.9	45.9	21.0	30.1
85-97	30.5	21.5	26.5	31.1	20.3	22.9	37.7	19.1	26.1
80-97	32.7	19.3	24.4	23.1	15.0	16.9	38.5	16.6	22.8

Table 3.2.5 Inner South Coast enhanced facilities contribution to natural escapement 1992-1997.

~~Rtn Yr~~	~~Puntledge~~	~~L.Qualicum~~	~~Chilliwack~~	~~Chehalis~~	~~Inch~~	~~Stave~~	~~Total~~	~~Inside~~	~~Fraser~~
1992	17,731	6,663	20,048	15,538	829	75,702	136,511	24,394	112,117
1993	5,888	51,397	67,220	11,466	2,050	113,662	251,683	57,285	194,398
1994	18,217	69,745	45,318	20,542	2,494	6,656	162,972	87,962	75,010
1995	10,500	4,666	22,332	517	1,996	19,895	59,906	15,166	44,740
1996	2,544	9,929	21,890	3,448	634	45,340	83,785	12,473	71,312
~~1997*~~		~~12,016~~	~~9,083~~	~~25,563~~	~~2,129~~	~~36,759~~	~~85,549~~	~~12,016~~	~~73,533~~
Mean	10,976	25,736	30,982	12,846	1,689	49,669	131,897	36,712	95,185

*Puntledge 1997 escapement is unavailable

Table 3.3.1 Inner South Coast enhanced facilities commercial net exploitation rate (does not include non-sampled strata including U.S., troll, sport, or native catches)

Rtn Yr	Puntledge	Big Qualicum	L Qualicum	Chilliwack	Chehalis	Blaney	Inch	Stave	Inside	Fraser	Total
1980		50.3				52.5	52.5		50.3	52.5	50.4
1981		34.2				7.3	1.9		34.2	5.6	33.1
1982	59.8	59.8	18.7			49.0	20.2		58.1	24.5	57.3
1983	40.7	40.8	13.9	0.0		12.0	0.0		38.2	1.0	37.5
1984	48.6	59.9	29.4	28.2		0.0	45.7		55.3	27.6	54.2
1985	69.6	68.4	66.3	22.0	18.4	10.3	13.3	4.9	68.1	15.0	58.7
1986	67.1	66.6	67.5	58.3	31.9	33.9	17.0	22.7	66.9	36.3	58.3
1987	66.3	65.1	67.4	9.5	7.3	42.4	9.7	11.3	65.9	8.8	55.8
1988	62.2	57.9	60.3	71.2	52.4	77.4	47.7	48.1	59.0	55.9	57.3
1989	53.6	59.9	54.3	33.5	30.9	25.1	64.8	20.9	57.7	28.7	41.5
1990	50.4	75.1	59.3	65.5	33.4	56.4	58.7	43.2	67.2	40.8	55.7
1991	90.6	68.2	34.9	24.1	14.5		22.8	13.0	63.7	16.1	47.5
1992	54.9	87.2	76.8	54.1	44.1		29.9	33.7	83.9	41.3	75.4
1993	87.1	73.1	57.7	28.1	51.9		48.1	25.7	70.4	33.3	60.2
1994	56.4	70.9	53.5	31.0	52.2		21.6	43.0	63.9	40.7	58.0
1995	20.5	30.2	18.8	18.5	28.1		27.0	26.3	25.7	24.9	25.3
1996	0.0	3.5	3.1	7.4	0.0		0.0	0.4	3.1	1.8	2.2
1997*	3.3	3.3	2.8	9.2	0.8		0.0	5.5	3.2	2.9	3.0
Total											
80-84	47.8	51.3	21.9	27.4		17.0	24.6		49.4	23.1	48.6
85-89	66.3	65.4	64.7	47.0	34.1	42.9	24.9	27.9	65.3	35.1	55.6
90-94	68.5	77.3	58.9	36.6	37.7	56.4	33.6	32.2	72.1	35.5	61.8
95-97	10.0	13.4	9.7	12.0	9.0		4.5	9.3	12.0	9.2	10.5
85-94	67.3	72.8	61.2	41.0	35.9		29.1	30.6	69.4	35.3	59.2
85-97	63.1	70.0	58.8	36.9	32.3		22.0	28.4	66.5	31.9	55.5
All	62.0	66.2	57.2	36.8	32.3	39.0	22.3	28.4	63.9	31.8	54.7
Annual Mean											
80-84	49.7	49.0	20.7	14.1		24.2	24.1		47.2	22.2	46.5
85-89	63.7	63.6	63.2	38.9	28.2	37.8	30.5	21.6	63.5	28.9	54.3
90-94	67.9	74.9	56.4	40.6	39.2	56.4	36.2	31.7	69.8	34.4	59.4
95-97	7.9	12.3	8.2	11.7	9.6		9.0	10.7	10.7	9.9	10.2
85-94	65.8	69.2	59.8	39.7	33.7	40.9	33.4	26.7	66.7	31.7	56.8
85-97	52.5	56.1	47.9	33.2	28.2	40.9	27.7	23.0	53.7	26.7	46.1
All	51.9	54.1	42.8	30.7	28.2	33.3	26.7	23.0	51.9	25.4	46.2

*Data for 1997 is preliminary. Puntledge 1997 exploitation rate is estimated from Big Qualicum.

Table 3.3.2 Inner South Coast enhanced chum % distribution of contribution by area of catch and escapement (does not include strata not sampled-U.S., Troll, Sport, Native).

Non Fraser Enhanced Stocks (Puntledge, Big & Little Qualicum)

Rtn Yr	Area 2-10	Area 25-27	Area 21-24	Area 11-13	Area 14-20	Area 29	Tot Marine	Rack*	Brood*	Natural	Tot Esc
1980	0.0	0.0	0.0	12.7	37.6	0.0	50.3			49.7	49.7
1981	0.0	0.0	0.0	0.0	34.2	0.0	34.2			65.8	65.8
1982	0.0	0.0	0.0	21.0	37.1	0.0	58.1			41.9	41.9
1983	0.0	0.0	0.0	0.0	38.2	0.0	38.2			61.8	61.8
1984	0.0	0.0	0.0	0.0	55.3	0.0	55.3			44.7	44.7
1985	0.0	0.0	0.0	12.7	55.4	0.0	68.1			31.9	31.9
1986	0.0	0.0	0.0	31.4	35.5	0.0	66.9			33.1	33.1
1987	0.0	0.0	0.0	3.3	62.6	0.0	65.9			34.1	34.1
1988	0.0	0.0	2.5	48.2	8.3	0.0	59.0			41.0	41.0
1989	0.0	0.0	0.9	26.7	30.1	0.0	57.7			42.3	42.3
1990	0.0	0.0	0.0	49.8	17.4	0.0	67.2			32.8	32.8
1991	0.0	0.0	0.0	8.6	55.1	0.0	63.7			36.3	36.3
1992	0.0	0.0	0.2	49.4	34.2	0.1	83.9	0.6	6.8	8.7	16.1
1993	0.2	0.0	0.0	38.6	30.3	1.3	70.4	5.0	9.3	15.3	29.6
1994	0.0	0.0	0.0	31.0	32.9	0.0	63.9	2.5	23.0	10.6	36.1
1995	0.0	0.0	0.2	23.1	2.4	0.0	25.7	0.0	63.6	10.7	74.3
1996	0.0	0.0	0.0	3.1	0.0	0.0	3.1	0.0	79.3	17.7	96.9
1997	0.0	0.0	0.0	3.2	0.0	0.0	3.2	0.6	30.1	66.1	96.8
Annual Mean											
80-84	0.0	0.0	0.0	6.7	40.5	0.0	47.2			52.8	52.8
85-89	0.0	0.0	0.7	24.5	38.4	0.0	63.5			36.5	36.5
90-94	0.0	0.0	0.0	35.5	34.0	0.3	69.8	2.7	13.0	20.7	30.2
95-97	0.0	0.0	0.1	9.8	0.8	0.0	10.7	0.2	57.7	31.5	89.3
85-94	0.0	0.0	0.4	30.0	36.2	0.1	66.7	2.7	13.0	28.6	33.3
85-97	0.0	0.0	0.3	25.3	28.0	0.1	53.7	1.4	35.3	29.3	46.3
All	0.0	0.0	0.2	20.2	31.5	0.1	51.9	1.4	35.3	35.8	48.1

* Rack sales and broodstock only separated in database since 1992. Inside brood includes spawning channel spawners.

Fraser Enhanced Stocks (Chilliwack, Chehalis, Blaney, Inch, Stave)

Rtn Yr	Area 2-10	Area 25-27	Area 21-24	Area 11-13	Area 14-20	Area 29	Tot Marine	Rack*	Brood*	Natural	Tot Esc
1980	0.0	0.0	0.0	36.9	2.1	13.5	52.5			47.5	47.5
1981	0.0	0.0	0.0	4.2	0.5	0.9	5.6			94.4	94.4
1982	0.0	0.0	0.0	11.1	0.3	13.1	24.5			75.5	75.5
1983	0.0	0.0	0.0	0.9	0.0	0.1	1.0			99.0	99.0
1984	0.0	0.0	0.0	0.5	27.1	0.0	27.6			72.4	72.4
1985	0.0	0.0	0.2	11.4	0.3	3.1	15.0			85.0	85.0
1986	0.0	0.3	0.0	29.1	2.0	4.9	36.3			63.7	63.7
1987	0.0	0.0	1.1	3.6	2.7	1.3	8.8			91.2	91.2
1988	0.0	0.0	1.3	44.9	0.7	9.0	55.9			44.1	44.1
1989	0.0	0.0	1.1	24.8	0.5	2.3	28.7			71.3	71.3
1990	0.0	0.0	0.0	31.3	1.3	8.1	40.8			59.2	59.2
1991	0.0	0.0	0.5	6.1	3.4	6.1	16.1			83.9	83.9
1992	0.0	0.0	2.3	31.9	1.9	5.2	41.3	17.1	5.4	36.1	58.7
1993	0.3	0.0	0.2	24.4	2.3	6.2	33.3	13.0	5.9	47.7	66.7
1994	0.0	0.0	0.7	29.9	1.3	8.7	40.7	18.0	15.7	25.6	59.3
1995	0.0	0.0	0.3	11.4	0.9	12.4	24.9	31.8	10.0	33.3	75.1
1996	0.0	0.0	0.0	1.8	0.0	0.0	1.8	36.9	9.4	51.9	98.2
1997	0.0	0.0	0.0	2.9	0.0	0.0	2.9	45.9	8.7	42.5	97.1
Annual Mean											
80-84	0.0	0.0	0.0	10.7	6.0	5.5	22.2			77.8	77.8
85-89	0.0	0.1	0.7	22.8	1.2	4.1	28.9			71.1	71.1
90-94	0.1	0.0	0.7	24.7	2.0	6.9	34.4	16.0	9.0	50.5	65.6
95-97	0.0	0.0	0.1	5.4	0.3	4.1	9.9	38.2	9.4	42.5	90.1
85-94	0.0	0.0	0.7	23.7	1.6	5.5	31.7	16.0	9.0	60.8	68.3
85-97	0.0	0.0	0.6	19.5	1.3	5.2	26.7	27.1	9.2	56.6	73.3
All	0.0	0.0	0.4	17.1	2.6	5.3	25.4	27.1	9.2	62.5	74.6

* Rack sales and broodstock only separated in database since 1992.

Table 3.4 Fry-to-adult survivals of fed and unfed chum salmon fry released from SEP Operations major facilities (1978-1992 brood years)

FRY-TO-ADULT SURVIVAL BY BROOD YEAR (RECOVERIES TO 1997)

																MEAN	MEAN	MEAN	MEAN	ODD	EVEN
HATCHERY	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	78-92	78-82	83-87	88-92	79-91	78-92
	FED FRY RELEASES																				
NON-FRASER																TARGET SURVIVAL-1.5%					
PUNTLEDGE		1.64	0.21	3.23	2.21	1.89	0.20	0.47	1.79	1.08	1.86	1.91	1.38	0.30	0.18	1.31	1.82	1.09	1.13	1.50	1.12
BIG QUALICUM			0.12	1.87	3.21											1.73	1.73			1.87	1.67
LITTLE QUALICUM			0.25	2.34	3.29	1.32	0.87	0.76	0.74							1.37	1.96	0.92		1.47	1.29
NON-FRASER TOTAL		1.64	0.18	2.49	2.65	1.73	0.40	0.57	1.33	1.08	1.86	1.91	1.38	0.30	0.18	1.26	1.74	1.02	1.13	1.39	1.14
FRASER																					
CHILLIWACK			0.19	1.25	2.62	1.27	2.24	0.78	1.34	0.92	2.30	3.76	2.17	0.74	0.62	1.55	1.35	1.31	1.92	1.45	1.91
INCH	0.54	0.54	0.59	1.40	0.43	0.74	0.79	0.32	0.66	0.45	1.61	1.01	2.04	1.30	0.31	0.85	0.70	0.59	1.25	0.82	1.00
STAVE					5.02	0.09	1.39	2.16	2.93	0.82	2.31	3.35	1.86	0.59	0.24	1.89	5.02	1.48	1.67	1.40	2.75
BLANEY	0.26	0.33	0.56	0.19	3.36	0.09	0.82	1.34	0.37							0.82	0.94	0.66		0.49	1.08
CHEHALIS					2.74	0.28	1.03	1.05	1.86	0.62	0.82	0.84	0.85	0.44	0.21	0.98	2.74	0.97	0.63	0.64	1.50
FRASER TOTAL	0.50	0.50	0.42	1.00	2.69	0.35	1.23	1.18	1.90	0.69	1.36	1.90	1.29	0.55	0.29	1.06	1.02	1.07	1.08	0.88	1.38
	UNFED FRY RELEASES																				
NON-FRASER																TARGET SURVIVAL-0.7%					
BIG QUALICUM	0.65	0.50	0.22	0.98	1.13	0.47	0.83	0.35	0.84	0.35	1.89	1.10	0.92	0.21	0.04	0.70	0.70	0.57	0.83	0.57	0.93
LITTLE QUALICUM		0.68	0.21	0.46	1.28	0.33	0.32	0.39	0.37	0.18	0.81	0.81	0.56	0.15	0.02	0.47	0.66	0.32	0.47	0.43	0.59
NON-FRASER TOTAL	0.65	0.52	0.22	0.97	1.17	0.44	0.59	0.36	0.63	0.28	1.49	0.99	0.74	0.18	0.03	0.62	0.71	0.46	0.69	0.53	0.79

Table 3.5.1 Inner South Coast enhanced chum age composition by brood year for the catch and escapement of Inside Non-Fraser and Fraser stoc

Non Fraser Enhanced Stocks (Puntledge, Big & Little Qualicum)

Br.Yr.	Catch at Age					Escapement at Age					Catch + Escapement at Age				
	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6
1977	0.0	43.6	47.8	8.5	0.0	0.0	30.6	65.3	4.1	0.0	0.0	36.0	58.0	5.9	0.0
1978	0.0	3.7	89.0	7.3	0.0	0.0	9.5	80.0	10.6	0.0	0.0	6.1	85.1	8.7	0.0
1979	0.0	35.4	55.3	9.3	0.0	0.0	24.6	71.7	3.7	0.0	0.0	29.5	64.3	6.2	0.0
1980	0.0	12.8	83.0	4.2	0.0	0.0	34.2	65.8	0.0	0.0	0.0	23.0	74.8	2.2	0.0
1981	0.0	22.0	73.4	4.5	0.0	0.0	44.5	52.7	2.8	0.0	0.0	29.1	66.9	4.0	0.0
1982	0.0	33.1	62.3	4.3	0.3	0.0	36.1	56.2	7.3	0.4	0.0	34.2	60.1	5.4	0.3
1983	0.0	16.1	67.5	15.9	0.4	0.0	10.9	70.6	18.3	0.1	0.0	14.6	68.5	16.6	0.3
1984	0.0	4.8	75.3	19.9	0.1	0.0	2.1	77.2	20.7	0.0	0.0	3.6	76.1	20.3	0.0
1985	0.0	9.0	82.9	8.0	0.0	0.0	6.6	82.9	10.5	0.0	0.0	8.0	82.9	9.1	0.0
1986	0.0	6.1	63.4	29.5	1.0	0.0	10.7	70.3	18.8	0.2	0.0	7.5	65.4	26.3	0.8
1987	0.0	1.5	60.5	37.1	0.9	0.0	1.5	88.3	10.2	0.0	0.0	1.5	68.6	29.3	0.6
1988	0.0	0.9	74.3	23.6	1.2	0.0	11.1	54.9	33.1	0.8	0.0	3.1	70.2	25.6	1.1
1989	0.0	3.5	76.7	19.7	0.0	0.0	2.7	77.6	19.6	0.1	0.0	3.2	77.0	19.7	0.0
1990	0.0	7.6	87.9	4.5	0.0	0.0	4.4	80.7	14.9	0.1	0.0	6.3	85.1	8.6	0.0
1991	0.0	65.4	34.6	0.0	0.0	0.0	33.1	61.7	5.2	0.0	0.0	46.2	50.8	3.1	0.0
Total	**0.0**	**12.6**	**71.2**	**15.7**	**0.5**	**0.0**	**18.3**	**67.7**	**13.7**	**0.2**	**0.0**	**14.6**	**70.0**	**15.0**	**0.4**
Mean	**0.0**	**17.7**	**68.9**	**13.1**	**0.3**	**0.0**	**17.5**	**70.4**	**12.0**	**0.1**	**0.0**	**16.8**	**70.3**	**12.7**	**0.2**
Mn 81-90	**0.0**	**10.5**	**72.4**	**16.7**	**0.4**	**0.0**	**13.1**	**71.1**	**15.6**	**0.2**	**0.0**	**11.1**	**72.1**	**16.5**	**0.3**

Fraser Enhanced Stocks (Chilliwack, Chehalis, Blaney, Inch, Stave)

Br.Yr.	Catch at Age					Escapement at Age					Catch + Escapement at Age				
	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6
1977	0.0	80.6	9.0	10.4	0.0	0.0	36.3	58.5	5.1	0.0	0.0	51.1	42.0	6.9	0.0
1978	0.0	0.1	99.5	0.4	0.0	0.0	26.5	71.4	2.0	0.0	0.0	21.0	77.3	1.7	0.0
1979	0.0	92.5	7.5	0.0	0.0	0.0	56.3	42.7	1.0	0.0	0.0	60.4	38.7	0.9	0.0
1980	0.0	0.0	100.0	0.0	0.0	0.0	62.0	37.3	0.7	0.0	0.0	45.7	53.8	0.5	0.0
1981	0.0	11.0	58.5	30.5	0.0	0.0	14.3	82.5	3.2	0.0	0.0	13.5	76.9	9.6	0.0
1982	0.0	13.2	84.3	2.4	0.2	0.0	33.3	62.4	4.3	0.0	0.0	27.4	68.8	3.7	0.1
1983	0.0	32.3	32.3	35.2	0.1	0.0	10.4	81.8	7.8	0.0	0.0	13.8	74.0	12.2	0.0
1984	0.0	0.5	92.4	7.0	0.1	0.0	11.9	80.2	7.8	0.1	0.0	5.3	87.2	7.4	0.1
1985	0.0	38.4	58.6	3.0	0.0	0.0	23.7	73.9	2.4	0.0	0.0	28.6	68.8	2.6	0.0
1986	0.0	7.6	82.3	10.1	0.1	0.0	14.4	64.5	20.9	0.2	0.0	12.0	70.8	17.1	0.2
1987	0.0	5.3	62.1	32.6	0.0	0.0	1.7	86.9	11.3	0.1	0.0	2.7	80.1	17.1	0.1
1988	0.0	0.7	86.3	12.9	0.1	0.0	17.6	72.6	9.7	0.2	0.0	11.1	77.9	10.9	0.1
1989	0.0	9.6	79.1	11.2	0.1	0.0	10.8	82.0	7.1	0.0	0.0	10.4	81.1	8.4	0.1
1990	0.0	12.1	79.8	8.1	0.0	0.0	10.8	73.7	15.3	0.1	0.0	11.3	76.0	12.6	0.1
1991	0.0	37.1	61.6	1.3	0.0	0.0	18.7	70.4	10.9	0.0	0.0	24.6	67.6	7.8	0.0
Total	**0.0**	**12.0**	**78.8**	**9.1**	**0.1**	**0.0**	**17.7**	**72.6**	**9.6**	**0.1**	**0.0**	**15.7**	**74.8**	**9.4**	**0.1**
Mean	**0.0**	**22.7**	**66.2**	**11.0**	**0.0**	**0.0**	**23.2**	**69.4**	**7.3**	**0.1**	**0.0**	**22.6**	**69.4**	**8.0**	**0.0**
Mn 81-90	**0.0**	**13.1**	**71.6**	**15.3**	**0.1**	**0.0**	**14.9**	**76.0**	**9.0**	**0.1**	**0.0**	**13.6**	**76.1**	**10.2**	**0.1**

Study Area Enhanced Stocks (Puntledge, Big & Little Qualicum, Chilliwack, Chehalis, Blaney, Inch, Stave)

Br.Yr.	Catch at Age					Escapement at Age					Catch + Escapement at Age				
	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6
1977	0.0	45.2	46.2	8.6	0.0	0.0	31.0	64.9	4.1	0.0	0.0	36.8	57.2	6.0	0.0
1978	0.0	3.7	89.1	7.3	0.0	0.0	10.0	79.7	10.3	0.0	0.0	6.4	85.0	8.6	0.0
1979	0.0	35.7	55.1	9.2	0.0	0.0	25.6	70.8	3.6	0.0	0.0	30.0	63.9	6.1	0.0
1980	0.0	12.5	83.3	4.1	0.0	0.0	36.0	63.9	0.0	0.0	0.0	24.0	73.9	2.1	0.0
1981	0.0	21.6	72.9	5.5	0.0	0.0	38.0	59.1	2.9	0.0	0.0	27.5	67.9	4.5	0.0
1982	0.0	30.2	65.5	4.0	0.3	0.0	34.9	58.8	6.0	0.2	0.0	32.4	62.4	5.0	0.2
1983	0.0	16.7	66.4	16.6	0.4	0.0	10.8	73.9	15.2	0.1	0.0	14.5	69.2	16.1	0.3
1984	0.0	2.6	83.8	13.5	0.1	0.0	6.9	78.7	14.3	0.0	0.0	4.5	81.6	13.9	0.1
1985	0.0	25.0	69.7	5.3	0.0	0.0	19.8	75.9	4.3	0.0	0.0	22.0	73.3	4.7	0.0
1986	0.0	6.5	68.3	24.4	0.8	0.0	13.0	66.8	20.0	0.2	0.0	9.3	67.7	22.5	0.5
1987	0.0	2.1	60.7	36.5	0.8	0.0	1.6	87.6	10.8	0.0	0.0	1.9	72.1	25.6	0.5
1988	0.0	0.9	75.3	22.7	1.1	0.0	13.5	61.3	24.6	0.6	0.0	4.4	71.5	23.2	1.0
1989	0.0	4.7	77.2	18.0	0.0	0.0	7.0	80.0	13.0	0.1	0.0	5.7	78.4	15.8	0.1
1990	0.0	8.5	86.3	5.2	0.0	0.0	6.9	77.9	15.1	0.1	0.0	7.8	82.5	9.7	0.0
1991	0.0	53.6	45.9	0.6	0.0	0.0	25.8	66.2	8.1	0.0	0.0	35.9	58.8	5.3	0.0
Total	**0.0**	**12.5**	**72.5**	**14.6**	**0.4**	**0.0**	**18.1**	**69.8**	**12.0**	**0.2**	**0.0**	**14.9**	**71.3**	**13.5**	**0.3**
Mean	**0.0**	**18.0**	**69.7**	**12.1**	**0.2**	**0.0**	**18.7**	**71.0**	**10.2**	**0.1**	**0.0**	**17.5**	**71.0**	**11.3**	**0.2**
Mn 81-90	**0.0**	**11.9**	**72.6**	**15.2**	**0.3**	**0.0**	**15.2**	**72.0**	**12.8**	**0.1**	**0.0**	**13.0**	**72.7**	**14.1**	**0.3**

Table 3.5.2 Inner South Coast chum age composition by brood year for Inside Non-Fraser and Fraser stocks.

	Catch + Escapement at Age				
Br.Yr.	2	3	4	5	6
Inside Non Fraser Stocks					
Enhanced	0.0	11.1	72.1	16.5	0.3
Enh+Wild	0.0	12.4	71.6	16.0	0.0
Fraser Stocks					
Enhanced	0.0	13.6	76.1	10.2	0.1
Enh+Wild	0.0	12.1	69.7	18.2	0.0
Study Area Stocks					
Enhanced	0.0	13.0	72.6	14.1	0.3
Enh+Wild	0.0	12.2	71.0	16.8	0.0

Table 4.1. Average total escapement, wild escapement, and enhancement contribution by major geographic areas for Inner South Coast (ISC) chum salmon stocks from 1953 to 1997. ISC includes Inside Study Area (ISA), Seymour/ Belize Inlets and Summer chum stocks. Total escapement includes natural river spawners (wild and enhanced), hatchery broodstock, and hatchery rack sale. Total non-enhanced is total escapement from non-enhanced systems. Total enhanced is total escapement from enhanced systems. Listed stocks have at least one escapement record. Target is the target escapement for each system. N is the number of years of data available for each system (maximum is 45 years). Systems surveyed are the number of systems surveyed in each region or time period.

				AVERAGE					
REGION/SYSTEM	TARGET	SOURCE	N	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
SEYMOUR/BELIZE INLETS									
ALLISON RIVER	1500	Wild	4	16	180				43
BAMFORD CREEK	2000	Wild	26		38	508	123	704	258
CHIEF NOWLEY CREEK	1500	Wild	25	6	55	106	30	789	166
DRIFTWOOD CREEK	20000	Wild	42	1056	2295	6720	2753	3679	3375
EVA CREEK	3500	Wild	25	88	140	758	150	700	357
JAP CREEEK	20000	Wild	40	483	1940	4158	995	736	1776
LASSITER AND ROWLEY CREEKS	500	Wild	8		10	21	3	43	14
NUGENT CREEK	200	Wild	7		4	3		43	8
PACK LAKE CREEK	3500	Wild	21	906	100	5	45	2143	528
QUASHELLA RIVER	10000	Wild	36	918	3427	1411	123	729	1379
RAINBOW CREEK	5000	Wild	43	296	661	1361	608	1050	800
SCHWARTZENBERG LAGOON CRE	300	Wild	1		10				2
SEYMOUR RIVER	20000	Wild	45	5169	6498	6425	3825	5107	5435
TAALTZ CREEK	45000	Wild	44	4069	8501	15140	13350	15000	11277
WAAMTX CREEK	3500	Wild	37	172	126	565	33	1857	480
WARNER BAY CREEK	3500	Wild	43	778	605	1535	648	2486	1144
WAUMP CREEK	18000	Wild	43	2045	4355	5920	1405	2118	3269
WAWWATL CREEK	5500	Wild	6	999				4	178
WODEFORD CREEK	1500	Wild	2					271	42
	165000	Wild		13232	20085	29585	19260	26843	21845
			19	10	11	11	10	14	11

				AVERAGE					
REGION/SYSTEM	TARGET		N	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
UPPER VANCOUVER ISLAND									
CLUXEWE RIVER	5,000	Wild	36	94	83	152	830	2,357	620
KEOGH RIVER	15,000	Wild	28	6	53	436	2,145	4,279	1,252
NAHWITTI RIVER	5,000	Wild	17	95		77	278	868	231
QUATSE RIVER	10,000	Wild	41	231	161	454	5,065	10,143	2,881
SHUSHARTIE RIVER	1,500	Wild	18	9		27	275	682	175
SONGHEES CREEK	500	Wild	10	47		3	63	300	69
STRANBY RIVER	25,000	Wild	8	9		75	20	3,643	589
TSULQUATE RIVER	5,000	Wild	30	84	51	177	585	1,004	352
TOTAL	67,000			575	347	1,399	9,260	23,275	6,169
SYSTEMS SURVEYED			8	3	2	4	6	7	4

Table 4.1. Continued

			AVERAGE						
REGION/SYSTEM	TARGET		N	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
KINGCOME INLET									
BUGHOUSE CREEK	500	Wild	3					718	112
CHARLES CREEK	500	Wild	8	3	2			393	62
COHOE CREEK		Wild	1			1			0
EMBLEY CREEK		Wild	7		51			929	156
HUASKIN CREEK	500	Wild	17		114	325	20		102
JENNIS BAY CREEK	1,000	Wild	3		8		3		2
KENNETH RIVER	500	Wild	1		5				1
KINGCOME RIVER	150,000	Wild	40	1,293	2,738	22,270	11,200	12,286	10,187
MACKENZIE SOUND CREEK	6,000	Wild	41	232	2,690	6,610	2,145	4,250	3,246
MARION CREEK	5,000	Wild	36	25	1,933	3,170	390	3,914	1,834
NIMMO CREEK	5,000	Wild	38	44	358	2,415	1,765	5,893	1,933
SCOTT COVE CREEK	5,000	Wild	28	7	230	90	20	575	166
SHELTER BAY CREEK	1,000	Wild	4		0			11	2
SIMOON SOUND CREEK		Wild	17	3	18	70	45	443	99
SULLIVAN BAY CREEK		Wild	5					18	3
WAKEMAN RIVER	25,000	Wild	41	288	2,307	5,055	2,450	6,857	3,298
TOTAL	200,000			1,893	10,451	40,006	18,038	36,286	21,202
SYSTEMS SURVEYED			16	3	8	7	6	10	6

			AVERAGE						
REGION/SYSTEM	TARGET		N	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
BOND/KNIGHT INLETS									
AHTA RIVER	20,000	Wild	45	1,216	3,498	11,520	9,820	10,929	7,436
AHTA VALLEY CREEK	20,000	Wild	24	1	85	340	490	3,071	681
BOUGHEY CREEK	100	Wild	12	25	27		48	86	34
CALL CREEK	600	Wild	37	137	365	1,708	570	829	741
CRACROFT CREEK	100	Wild	1					4	1
FRANKLIN RIVER	3,000	Wild	21			325	805	1,521	488
GILFORD CREEK	300	Wild	27		15	110	170	593	158
GLENDALE CREEK	75,000	Wild	44	3,352	1,880	9,730	18,858	4,929	8,133
HOEYA SOUND CREEK	100	Wild	14	5			125	632	127
KAKWEIKEN RIVER	75,000	Wild	43	1,160	1,945	4,120	3,100	10,557	3,885
KAMANO BAY CREEK	100	Wild	5					200	31
KLINAKLINI RIVER	100,000	Wild	34	327	100	11,500	9,408	17,429	7,438
KWALATE CREEK	300	Wild	32	45	106	50	138	443	142
LULL CREEK	100	Wild	31	13	7	185	230	782	218
MAPLE CREEK	100	Wild	3					61	9
MATSIU CREEK	100	Wild	9	6	40		3	75	22
MCALISTER CREEK		Wild	11	1	5	20			6
NIGGER CREEK		Wild	8				15	21	7
PORT HARVEY LAGOON CREEKS		Wild	8				33	39	13
PROTECTION POINT CREEK		Wild	9				10	71	13
SHOAL CREEK	100	Wild	7				75	21	20
SHOAL HARBOUR CREEK	1,000	Wild	43	45	1,195	1,163	1,800	6,000	1,865
SIM RIVER	10,000	Wild	24	34	126	31	1,028	1,807	550
VINER SOUND CREEK	40,000	Wild	45	4,138	25,420	27,500	30,640	55,000	27,860
WAHKANA BAY CREEK		Wild	24	0	5	13	53	911	157
TOTAL	346,000			10,506	34,819	68,313	77,415	116,011	60,035
SYSTEMS SURVEYED			24	8	10	11	15	20	12

Table 4.1. Continued

			AVERAGE						
REGION/SYSTEM	TARGET		N	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
JOHNSTONE STRAIT									
ADAM RIVER	5,000	Wild	18	188		75	845	2,929	693
AMOR DE COSMOS CREEK	10,000	Wild	33	22	68	678	358	443	318
FULMORE RIVER	10,000	Wild	38	2,675	2,065	1,175	900	2,821	1,834
HYACINTHE BAY CREEK	10,000	Wild	44	783	2,780	2,800	1,620	3,000	2,206
HYDE CREEK	3,500	Wild	9	3		60	7		15
KOKISH RIVER	5,000	Wild	32	179	1	133	370	1,964	449
MILLS CREEK	2,500	Wild	25	51	131	16	163	761	196
NEW VANCOUVER CREEK		Wild	4					14	2
NIMPKISH RIVER	110,000	Wild	45	67,459	42,365	12,700	24,250	42,857	36,285
POTTS LAGOON CREEK		Wild	8	3				39	7
ROBBERS KNOB CREEK	500	Wild	10				8	32	7
SALMON RIVER	20,000	Wild	35	94	122	860	1,455	3,964	1,175
TSITIKA RIVER	10,000	Wild	10			70	28	1,071	188
TUNA RIVER	3,500	Wild	25	44	175	73	115	757	206
WALDON CREEK		Wild	4					21	3
TOTAL	190,000			71,500	47,706	18,638	30,117	60,675	43,585
SYSTEMS SURVEYED			14	5	5	7	9	13	8

			AVERAGE						
REGION/SYSTEM	TARGET		N	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
LOUGHBOROUGH/BUTE INLETS									
APPLE RIVER	20,000	Wild	36	247	3,260	7,300	1,330	689	2,793
BACHUS CREEK		Wild	2		7				1
BIRD COVE CREEK	200	Wild	36	51	425	865	728	207	490
CAMELEON HARBOUR CREEK	100	Wild	33	23	25	25	158	243	88
CHONAT CREEK		Wild	8				3	25	4
CHRISTIE CREEK	100	Wild	41	78	360	453	655	46	347
CUMSACK RIVER	100	Wild	14			3	313	1,464	298
DREW CREEK	100	Wild	21	16	20	18	5	146	35
ELEPHANT CREEK	100	Wild	2		35				8
FANNY BAY CREEK	100	Wild	11	9	1	40	3	61	21
FORD CREEK	100	Wild	5	2				18	3
FRASER BAY CREEK	100	Wild	33	51	91	328	130	143	153
FREDERICK CREEK	100	Wild	12				163	189	66
GRANITE BAY CREEK	100	Wild	44	383	897	303	508	414	512
GRASSY CREEK	100	Wild	25	288	18	68	58	36	88
GRAY CREEK	100	Wild	22	429	35		80	29	106
HANSEN CREEK	100	Wild	28		318	198	223	118	182
HEMMING BAY CREEK	100	Wild	23	53	52		58	246	72
HEYDON CREEK	35,000	Wild	43	3,500	13,570	18,825	10,475	7,200	11,269
HOMATHKO RIVER	100,000	Wild	45	9,750	14,425	20,100	3,260	16,029	12,623
KANISH CREEK	100	Wild	42	63	891	360	543	421	475
KNOX BAY CREEK	100	Wild	16	3		23	70	39	27
OPEN BAY CREEK	200	Wild	42	675	1,683	918	1,003	732	1,035
OWEN CREEK	100	Wild	2		8				2
PHILLIPS RIVER	20,000	Wild	45	1,463	1,365	4,275	2,605	3,843	2,690
QUATAM RIVER	300	Wild	38	1,297	593	2,565	1,165	3,079	1,670
READ CREEK	100	Wild	38	123	242	705	998	629	552
SOUTHGATE RIVER	250,000	Wild	44	66,875	106,700	36,200	6,650	7,429	46,278
STAFFORD RIVER	4,000	Wild	35	6,888	203	1,180	1,368	768	1,955
TEAQUAHAN RIVER	100	Wild	23	144	305	40	350	1,179	363
THURSTON BAY CREEK	100	Wild	37	29	233	195	365	96	196
VILLAGE BAY CREEK	5,000	Wild	41	396	2,030	1,730	1,125	2,950	1,615
WAIATT BAY CREEK	100	Wild	41	79	138	123	128	114	118
WHITEROCK PASS CREEK	100	Wild	37	16	94	220	145	129	125
WORTLEY CREEK	100	Wild	41	531	2,380	210	283	175	760
TOTAL	437,000			93,460	150,400	97,265	34,940	48,886	87,021
SYSTEMS SURVEYED			35	18	20	21	26	29	22

Table 4.1. Continued

				AVERAGE					
REGION/SYSTEM	TARGET		N	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
MID VANCOUVER ISLAND									
BOB CREEK	200	Wild	11	152	14				30
CABIN CREEK	200	Wild	3	8	30				8
CAMPBELL RIVER	10,000	Wild	43	6,313	3,555	4,820	1,305	1,414	3,493
CHEF CREEK	5,000	Wild	45	1,925	3,265	4,065	1,630	3,286	2,844
COWIE CREEK	2,000	Wild	43	398	369	307	755	2,429	766
ENGLISHMAN RIVER	4,000	Wild	45	2,756	1,620	4,825	3,575	8,321	4,011
FRENCH CREEK	1,000	Wild	34	63	60	450	500	936	381
HART CREEK	500	Wild	13	73	3	18			18
KINGFISHER CREEK	200	Wild	1		1				0
KITTY COLEMAN CREEK	300	Wild	2			5			1
LITTLE QUALICUM RIVER	130,000	Wild	45	72,563	54,472	53,250	42,500	35,000	51,727
LYMN CREEK	200	Wild	30	87	37	45	56	104	62
MCNAUGHTON CREEK	2,000	Wild	45	481	802	1,900	863	5,214	1,689
MENZIES CREEK	800	Wild	39	19	126	230	390	554	255
MILLARD CREEK	200	Wild	13	174	41				40
MOHUN CREEK	800	Wild	36	125	524	208	245	546	324
MORRISON CREEK	200	Wild	22	2,075	555			54	501
NILE CREEK	1,000	Wild	43	556	84	65	143	186	193
OYSTER RIVER	3,500	Wild	41	1,025	72	460	483	5,500	1,263
PUNTLEDGE RIVER	60,000	Wild	44	56,839	59,976	40,600	33,400	32,143	44,877
PYE CREEK	500	Wild	24	1	68	33	113	100	63
QUALICUM RIVER		Wild	5					22,143	3,444
QUINSAM RIVER	2,000	Wild	38	171	467	651	480	743	501
ROSEWALL CREEK	200	Wild	41	713	1,168	1,070	1,775	2,929	1,474
ROY CREEK	300	Wild	11	78	6				15
SHAW CREEK		Wild	1	25					4
SIMMS CREEK		Wild	2	1					0
STORIE CREEK		Wild	1		1				0
TRENT RIVER	1,400	Wild	36	738	435	850	183		457
TSABLE RIVER	7,000	Wild	43	2,025	2,205	4,970	6,525	8,000	4,649
TSOLUM RIVER	1,500	Wild	36	1,250	3,008	118	768	636	1,186
WATERLOO CREEK	2,000	Wild	43	88	145	385	560	1,807	539
WILFRED CREEK	2,500	Wild	45	382	493	990	868	1,475	820
WOODS		Wild	1		2				0
TOTAL	239,500			151,100	133,600	120,313	97,113	133,518	125,637
SYSTEMS SURVEYED			33	23	20	20	20	21	21

				AVERAGE					
REGION/SYSTEM	TARGET		N	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
TOBA INLET									
BREM RIVER	15,000	Wild	33	46	33	1,255	1,480	3,457	1,161
BREM RIVER TRIBUTARY		Wild	7	1				21	4
FILER CREEK		Wild	1			3			1
FORBES BAY CREEK	5,000	Wild	36	12	129	341	197	529	233
FORBES CREEK		Wild	36	18	270	859	525	3,429	904
KLITE RIVER	15,000	Wild	31	8	290	1,085	2,515	2,393	1,238
LITTLE TOBA RIVER	20,000	Wild	26		750	1,700	2,598	821	1,249
OKEOVER CREEK	6,000	Wild	41	245	3,941	2,144	803	839	1,705
PENDRELL SOUND CREEK		Wild	30	14	135	106	278	300	164
REFUGE COVE LAGOON CREEK		Wild	17			10	90	111	39
SALT LAGOON CREEK		Wild	21			43	98	536	114
STORE CREEK		Wild	4		100	27			28
TAHUMMING RIVER		Wild	18			40	53	225	56
THEODOSIA RIVER	21,000	Wild	40	396	2,205	3,755	5,850	17,071	5,350
TOBA RIVER	90,000	Wild	30		2,180	4,350	7,250	22,500	6,562
TWIN RIVERS		Wild	1			56			12
TOTAL	172,000			740	10,033	15,772	21,735	52,232	18,821
SYSTEMS SURVEYED			15	3	6	9	12	12	8

Table 4.1. Continued

			AVERAGE						
REGION/SYSTEM	TARGET		N	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
JERVIS INLET									
ANGUS CREEK	2,000	Wild	45	391	1,290	1,149	2,600	1,411	1,409
BAKER CREEK		Wild	10	2	25	36			14
BISHOP CREEK	12,000	Wild	40	1,423	7,373	11,936	12,550	5,214	8,144
BRITTAIN RIVER	5,000	Wild	44	459	247	243	676	1,129	516
BURNET CREEK		Wild	13	7	120	4			29
CARLSON CREEK	1,000	Wild	40	35	557	408	1,353	493	598
CRANBY CREEK		Wild	7	0	2	33			8
DAYTON CREEK		Wild	40	16	532	760	380	207	407
DESERTED RIVER	25,000	Wild	45	35,250	20,050	18,450	6,100	10,786	17,856
DORISTON CREEK		Wild	40	238	430	65	59	82	178
EARLE CREEK		Wild	5	3	80	20			23
GRAY CREEK	1,000	Wild	40	17	288	461	692	1,121	498
HALFMOON CREEK		Wild	11	33	69	8			23
HIGH CREEK		Wild	1		5				1
HUNAECHIN CREEK		Wild	12	1,219	450				317
JEFFERD CREEK	1,600	Wild	42	726	1,407	1,095	165	914	864
KELLY CREEK		Wild	41	632	1,845	893	193	468	836
LANG CREEK	2,500	Wild	44	11,276	2,220	1,992	2,815	4,714	4,299
LOIS RIVER		Wild	41	105	442	245	233	268	265
MILL CREEK		Wild	1		1				0
MOUAT CREEK		Wild	8		95	263	600		213
MYRTLE CREEK		Wild	41	20	510	547	365	414	384
PARK CREEK		Wild	3		523				116
PENDER HARBOUR CREEKS	17,000	Wild	44	2,336	7,819	7,780	3,455	5,214	5,460
SAKINAW LAKE	500	Wild	39	44	37	243	933	1,464	505
SECHELT CREEK		Wild	30	94	116	29	80	525	148
SHANNON CREEK		Wild	7	33	2				6
SKWAWKA RIVER	25,000	Wild	44	15,831	6,320	2,305	1,418	1,111	5,219
SLIAMMON CREEK	14,000	Wild	44	10,295	13,735	7,232	4,810	9,643	9,059
SNAKE CREEK	1,500	Wild	45	434	1,064	230	763	1,200	721
STORM CREEK	2,000	Wild	43	289	1,936	264	233	125	611
TSUAHDI CREEK		Wild	10	294	520				168
TZOONIE RIVER	25,000	Wild	45	23,875	20,965	12,870	14,450	13,214	17,030
VANCOUVER RIVER	5,000	Wild	45	1,816	1,403	2,085	1,438	3,786	2,006
WEST CREEK		Wild	16		231	440			149
WHITTAL CREEK		Wild	40	1,471	3,225	1,362	425	236	1,412
TOTAL	140,100			108,662	95,932	73,445	56,783	63,739	79,490
SYSTEMS SURVEYED			36	21	27	25	23	22	24

Table 4.1. Continued

				AVERAGE					
REGION/SYSTEM	TARGET		N	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
LOWER VANCOUVER ISLAND									
BECK CREEK	1,000	Wild	6	1	1	7			2
BLOODS CREEK	1,000	Wild	3		1		3	11	2
BONELL CREEK	10,000	Wild	43	44	4,143	2,867	2,200	5,679	2,938
BONSALL CREEK	3,000	Wild	43	103	505	800	208	836	484
BUSH CREEK	10,000	Wild	44	417	3,114	2,442	2,273	4,979	2,588
CHASE RIVER	1,500	Wild	21	150	227	61			91
DEPARTURE CREEK	1,500	Wild	9	2	9	0	0	0	2
HASLAM CREEK	2,500	Wild	15	3,654	3,245				1,371
HOLLAND CREEK	10,000	Wild	45	739	3,894	2,911	4,647	8,857	4,054
KNARSTON CREEK	1,000	Wild	8	1	4	0	5		2
MILLSTONE RIVER	1,000	Wild	9	47	20				13
NANAIMO RIVER	65,000	Wild	45	54,375	44,140	35,130	20,100	39,643	37,916
NANOOSE CREEK	15,000	Wild	45	268	2,842	6,030	1,003	1,854	2,531
NAPOLEON CREEK		Wild	4	1,063					189
PORTERS CREEK	1,000	Wild	15			1	14	54	12
ROCKEY CREEK	1,000	Wild	27	7	1	10	51	104	31
STOCKING CREEK	8,000	Wild	44	441	2,888	3,020	1,722	4,071	2,407
WALKERS CREEK	1,500	Wild	42	22	514	481	320	1,593	544
TOTAL	134,000			61,333	65,547	53,758	32,544	67,679	55,176
SYSTEMS SURVEYED			18	11	11	10	10	10	10

				AVERAGE					
REGION/SYSTEM	TARGET		N	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
SOUTH VANCOUVER ISLAND									
CHEMAINUS RIVER	50,000	Wild	45	12,406	23,670	13,175	9,200	23,714	16,127
COLQUITZ RIVER	3,000	Wild	3		1	1			0
COWICHAN RIVER	110,000	Wild	45	103,750	108,000	63,050	55,500	51,429	76,789
CRAIGFLOWER CREEK		Wild	1	0					0
FULFORD CREEK	3,000	Wild	4	6		10	3		4
GOLDSTREAM RIVER	15,000	Wild	45	30,894	27,850	7,850	6,950	6,857	16,037
KOKSILAH RIVER	20,000	Wild	41	2,875	4,900	4,350	5,250	2,286	4,089
SANDHILL CREEK	10,000	Wild	3	18					3
SHAWNIGAN CREEK	3,000	Wild	9	7	0	8	70		19
TOTAL	214,000			149,957	164,421	88,443	76,973	84,286	113,067
SYSTEMS SURVEYED			9	5	4	4	5	4	4

Table 4.1. Continued

			AVERAGE						
REGION/SYSTEM	TARGET		N	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
HOWE SOUND/SUNSHINE COAST									
ASHLU CREEK		Wild	38	372	503	2,293	400	375	835
AVALON CREEK		Wild	7	13		63			16
B.C. RAIL SPAWNING CHANNEL		Wild	10	866	540				274
BRANCH 100 CREEK		Wild	1	1					0
BRENNAN CHANNEL		Wild	8	731	50				141
BROHM RIVER		Wild	1			3			1
CENTRE CREEK		Wild	1	0					0
CHAPMAN CREEK	4,000	Wild	32	1,806	445	1,840	45		839
CHASTER CREEK		Wild	25	50	169	90			66
CHEAKAMUS RIVER	100,000	Wild	43	37,400	53,200	33,950	19,280	23,500	33,956
CHUK-CHUK CREEK		Wild	6	2	17	3			5
DAKOTA CREEK		Wild	11	5	41	10			12
DRYDEN CREEK		Wild	9	468	80				101
EAGLE CREEK		Wild	9	0	2	10			3
FLUME CREEK		Wild	8	2	3	13			4
HOP RANCH CREEK		Wild	5	1	14				3
JUDD SLOUGH		Wild	12	2,088	2,600				949
JULY CREEK		Wild	2	875					156
LANGDALE CREEK		Wild	20	3	10	73			19
LONG BAY CREEK		Wild	32	750	1,720	1,835	480		1,030
LOWER PARADISE CHANNEL		Wild	10	2,238	1,700				776
MAMQUAM RIVER	40,000	Wild	42	6,456	9,200	19,665	2,780	3,107	8,663
MAMQUAM SPAWNING CHANNEL		Wild	12	2,040	1,630				725
MANNION CREEK		Wild	25	39	288	292	50		147
MASHITER CREEK		Wild	6	18	25	3			9
MASHITER SPAWNING CHANNEL		Wild	9	709	288				190
MCNAB CREEK	10,000	Wild	35	98	738	525	150	104	347
MCNAIR CREEK		Wild	10	2	13	9			5
MEIGHAN CREEK		Wild	9	41	23				12
MISSION CREEK		Wild	2	475					84
MOODY CHANNEL		Wild	9	2,171	80				404
NELSON CREEK		Wild	16		2	29		179	35
OUILLET CREEK		Wild	30	61	360	1,224	425		457
PILLCHUCK CREEK		Wild	30	1	100	238	38	182	112
POTLATCH CREEK		Wild	3	1	8	20			6
RAINY RIVER		Wild	14	8	45	14			15
ROBERTS CREEK	1,500	Wild	32	325	1,357	1,223	640		773
SHOVELNOSE CREEK		Wild	16	122	315	1,033			321
SPRING CREEK		Wild	6	127	990				243
SQUAMISH RIVER	200,000	Wild	42	28,044	72,027	63,500	16,750	28,214	43,214
STAWAMUS RIVER		Wild	28	30	44	5	43	121	44
STAWAMUS SPAWNING CHANNEL		Wild	1	2					0
TENDERFOOT CREEK		Wild	18	2,634	2,672				1,062
TERMINAL CREEK		Wild	5	10	1				2
THIRTY SEVEN MILE CREEK		Wild	1			3			1
THIRTY SIX MILE CREEK		Wild	1		3				1
TIEMPO SPAWNING CHANNEL		Wild	8	314	8				57
TWENTY EIGHT MILE CREEK		Wild	7	108	12	3			22
TWIN CREEK		Wild	9	4	5	62			15
UPPER PARADISE CHANNEL		Wild	8	3,809	1,078				917
WAKEFIELD CREEK		Wild	21	19	142	455			136
WEST BAY CREEK	1,000	Wild	31	159	905	1,285	175		554
WHISPERING CREEK		Wild	5	29	11				8
WILDWOOD SPAWNING CHANNEL		Wild	1	13					2
WILLIAMSON CREEK		Wild	25	16	120	1,142	360		363
WILSON CREEK	1,000	Wild	24	487	319	109			182
TOTAL	357,500			96,039	153,898	131,015	41,615	55,782	98,313
SYSTEMS SURVEYED			56	25	26	22	10	8	18

Table 4.1. Continued

			AVERAGE						
REGION/SYSTEM	TARGET		N	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
BURRARD INLET									
BROTHERS CREEK	1,000	Wild	18	60	75	14			30
CAPILANO RIVER		Wild	42	40	202	457	65	764	287
HASTINGS CREEK		Wild	1	0					0
INDIAN RIVER	28,000	Wild	45	42,350	24,950	16,350	5,850	13,571	20,118
LYNN CREEK	1,000	Wild	30	15	9	47	23	61	29
MACKAY CREEK		Wild	8	5	1	0			1
MAPLEWOOD CREEK	1,000	Wild	11	39	5				8
MCCARTNEY CREEK		Wild	2	0	1				0
MOSQUITO CREEK		Wild	1	0					0
MOSSOM CREEK	1,000	Wild	12	383	196				112
NOONS CREEK		Wild	7	29					5
RICHARDS CREEK		Wild	1	0					0
SEYMOUR RIVER	1,000	Wild	39	558	1,017	150	28	732	478
TOTAL	33,000			43,479	26,457	17,018	5,965	15,129	21,069
SYSTEMS SURVEYED			13	7	6	4	4	4	5

			AVERAGE						
REGION/SYSTEM	TARGET		N	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
FRASER RIVER									
ALOUETTE RIVER		Wild	45	15,017	18,615	7,235	1,070	1,329	8,859
AMERICAN CREEK		Wild	8	2	27		5		7
ANDERSON RIVER		Wild	4		29				6
ATCHELITZ CREEK		Wild	1		2				0
BARRETT CREEK		Wild	12	654	37	157			159
BELCHARTON CREEK		Wild	27	16	33		20	82	27
BIG SILVER CREEK		Wild	24	16	67	73	50	14	47
BLANEY CREEK		Wild	42	874	2,356	785	428	318	998
BOISE CREEK		Wild	1	0					0
BORDEN CREEK		Wild	4	8	6				3
BOUCHIER CREEK		Wild	42	241	1,051	263	278	396	458
BROUSSEAU CREEK		Wild	7	60	160	8			48
BRUNETTE RIVER		Wild	10	66	14				15
CAMP SLOUGH		Wild	1		1				0
CEDAR CREEK		Wild	15	487	976				303
CENTER CREEK		Wild	1		9				2
CHEHALIS RIVER		Wild	44	62,338	53,955	41,040	24,916	20,643	40,940
CHILLIWACK CREEK		Wild	4		25				6
CHILLIWACK RIVER		Wild	45	195,428	153,812	69,215	66,220	12,414	100,951
CHILQUA CREEK		Wild	41	679	3,930	628	140	21	1,168
CLAYBURN CREEK		Wild	14	25	18	3	13	14	14
COGBURN CREEK		Wild	11		8	5	13	11	7
COHO CREEK		Wild	11	67	116				38
COQUIHALLA RIVER		Wild	36	158	315	144	58	79	155
COQUITLAM RIVER		Wild	44	738	923	1,149	63	1,150	784
DEPOT CREEK		Wild	2		7				2
DEROCHE CREEK		Wild	2	4					1
DOUGLAS CREEK		Wild	11		12	15	3		7
DRAPER CREEK		Wild	17	42	130	5			37
EAST CREEK		Wild	3		130				29
ELK CREEK		Wild	1		8				2
EMORY CREEK		Wild	1		5				1
FIFTEEN MILE CREEK		Wild	2	44	50				19
FLOODS CREEK		Wild	2		65				14
FOLEY CREEK		Wild	10	2	50	5			12
FOLEY CREEK SIDE CHANNEL		Wild	5	127	63				36

Table 4.1. Continued

REGION/SYSTEM	TARGET	AVERAGE						
		N	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
FRASER RIVER (CONT.)								
FOURTEEN MILE CREEK	Wild	1	0					0
GIESBRECHT SPAWNING CHANNEL	Wild	2		22				5
GREYELL SLOUGH	Wild	1		90				20
HARRISON RIVER	Wild	44	422,620	123,715	108,255	87,032	41,429	152,466
HAWKINS CREEK	Wild	16			5	95	21	26
HICKS CREEK	Wild	37	139	177	50	25	18	84
HOPE SLOUGH	Wild	2		3				1
HOPEDALE SLOUGH	Wild	18	2,125	1,632	195			784
HOY CREEK	Wild	18	432	616				214
HUNTER CREEK	Wild	33	62	76	27	13	25	40
HYDE CREEK	Wild	18	568	452				201
INCH CREEK	Wild	45	5,984	6,086	4,215	2,080	1,393	4,032
KANAKA CREEK	Wild	45	5,094	1,733	940	123	1,307	1,730
KATZ	Wild	1		60				13
KAWKAWA CREEK	Wild	43	244	553	219	25	46	227
KAWKAWA LAKE	Wild	2		85				19
KELLY CREEK	Wild	2		14				3
KENWORTHY CREEK	Wild	7	33	7				7
KOPP CREEK	Wild	2		10				2
LAGACE CREEK	Wild	26	240	150	118	5	32	108
LILLOOET RIVER	Wild	10	3,563	9,200				2,678
LIUMCHEN CREEK	Wild	1		1				0
LONZO CREEK	Wild	7		10	23			7
LORENZETTA CREEK	Wild	33	89	36	27	25	21	39
LUCKAKUCK CREEK	Wild	27	3	8	10	45	69	25
MACINTYRE CREEK	Wild	44	255	291	212	158	193	222
MAHOOD CREEK	Wild	30	286	279	105	23	68	152
MARIA SLOUGH	Wild	41	55	534	445	453	218	362
MENZ CREEK	Wild	2	1	5				1
MOUNTAIN SLOUGH	Wild	5	5	3	3			2
MYSTERY CREEK	Wild	20	56	3	30	30		24
NATHAN CREEK	Wild	14	24	7		18	118	28
NESAKWATCH CREEK	Wild	18	369	354	75	145		193
NICOMEN SLOUGH	Wild	38	52	4,447	3,005	1,115	1,311	2,117
NORRISH CREEK	Wild	38	88	2,384	3,250	848	354	1,511
NORTH ALOUETTE RIVER	Wild	43	1,053	2,765	1,313	328	1,379	1,380
OR CREEK	Wild	1		30				7
PEACH CREEK	Wild	15	3,648	2,374	115			1,202
PETERS SLOUGH	Wild	3	3	116				26
PITT RIVER	Wild	22	325	539	40	160	546	307
POST CREEK	Wild	1		10				2
PURCELL CREEK	Wild	2			3	3		1
PYE CREEK	Wild	2		2				0
RAILWAY CREEK	Wild	5	217					39
RANGER CREEK	Wild	3	181	32				39
RUBY CREEK	Wild	25	6	25	88	18		30
RYDER CREEK	Wild	24	11	485	284	157		208
SAKWI CREEK	Wild	12	19	363	158			119
SALMON RIVER	Wild	2	7	1				1
SALWEIN CREEK	Wild	32	75	79	32	54	39	56
SCHOOLHOUSE CREEK	Wild	2	9	0				2
SCOREY CREEK	Wild	20	64	293			18	79
SCOTT CREEK	Wild	14	112	132				49
SETON RIVER	Wild	3		1				0
SEVEN MILE CREEK	Wild	1	1					0
SIDDLE CREEK	Wild	31		13	30	43	50	27
SILVERDALE CREEK	Wild	43	221	657	440	349	289	406
SILVERHOPE CREEK	Wild	38	87	338	222	138	157	195

Table 4.1. Continued

			AVERAGE						
REGION/SYSTEM	TARGET		N	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
FRASER RIVER (CONT.)									
SLESSE CREEK		Wild	15	37	156	14	3		45
SLOQUET CREEK		Wild	2		40			57	18
SPUZZUM CREEK		Wild	4		18				4
SQUAWKUM CREEK		Wild	42	3,807	10,336	10,630	9,681	2,614	7,894
SQUEAH LAKE CREEK		Wild	1		10				2
STAVE RIVER		Wild	45	265,795	53,392	49,390	45,268	2,571	80,552
STEELHEAD CREEK		Wild	14	364	718	190			267
STEVEN CREEK		Wild	2		13				3
STREET CREEK		Wild	21	333	430	215	28		209
SUMAS RIVER		Wild	24		217	230	30	39	112
SWELTZER RIVER		Wild	35		8,312	5,100	3,900	4,179	4,497
TAMIHI CREEK		Wild	2	7	3				2
TEXAS CREEK		Wild	1		2				1
THURSTON CREEK		Wild	4	39	131				36
TIPELLA CREEK		Wild	3				3	57	9
TROUT LAKE CREEK		Wild	22	328	499	25	18	4	179
TWENTY MILE CREEK		Wild	19	70	35	35	88		47
WADES CREEK		Wild	6	116	3				21
WAHLEACH CREEK		Wild	38	149	433	162	131	107	204
WAHLEACH SLOUGH		Wild	13	183	5,356	360			1,303
WEAVER CREEK		Wild	43	4,689	35,575	22,570	2,940	1,075	14,575
WEST CREEK		Wild	38	278	35	198	163	846	269
WHONNOCK CREEK		Wild	42	849	1,348	1,065	708	786	966
WIDGEON CREEK		Wild	42	512	1,327	875	348	811	783
WORTH CREEK		Wild	38	340	1,497	413	125	393	571
YALE CREEK		Wild	1		10				2
YORKSON CREEK		Wild	1					4	1
TOTAL	700,000			1,003,409	518,178	336,126	250,204	99,115	439,248
SYSTEMS SURVEYED			121	41	62	45	42	41	47

			AVERAGE						
REGION/SYSTEM	TARGET		N	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
BOUNDARY BAY									
CAMPBELL RIVER	5,000	Wild	39	121	286	208	40	296	186
MURRAY CREEK		Wild	1	6					1
NICOMEKL RIVER		Wild	2	81					14
SERPENTINE RIVER		Wild	7	738	5				132
TOTAL	5,000			946	291	208	40	296	334
SYSTEMS SURVEYED			4	2	1	1	1	1	1

Table 4.1. Continued

REGION/SYSTEM	TARGET		N	AVERAGE					
				1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
SUMMER CHUM									
AHNUHATI RIVER	50,000	Wild	44	3960	11020	3530	6000	15571	7,693
ORFORD RIVER	80,000	Wild	44	22063	42050	50625	7150	10357	27,717
TOTAL	130,000			26023	53070	54155	13150	25929	35,410
SYSTEMS SERVEYED			2	2	2	2	2	2	2

REGION/SYSTEM	TARGET		N	AVERAGE					
				1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
ENHANCED									
QUATSE RIVER		Enhanced	8	36	43				16
KINGCOME RIVER		Enhanced	1		4				1
GLENDALE CREEK		Enhanced	3	1,450	820				440
NIMPKISH RIVER		Enhanced	9	695	380				208
ORFORD RIVER		Enhanced	2	250					44
PHILLIPS RIVER		Enhanced	6	150	990				247
LITTLE QUALICUM RIVER	30,000	Enhanced	16	42,582	34,738				15,290
PUNTLEDGE RIVER	5,000	Enhanced	14	5,310	4,133				1,862
QUALICUM RIVER	100,000	Enhanced	40	90,590	102,890	113,250	55,535	13,750	78,922
MID VAN IS		Rack	18	276	10,831	528			2,573
LANG CREEK		Enhanced	1		10				2
SLIAMMON CREEK		Enhanced	6	75	3,200				724
CHEMAINUS RIVER		Enhanced	3	1,250	1,890				642
MCNAB CREEK		Enhanced	1		11				2
CHEHALIS RIVER		Enhanced	14	9,368	10,128				3,916
CHILLIWACK RIVER		Enhanced	13	3,803	2,556				1,244
INCH CREEK		Enhanced	14	1,184	4,782				1,273
STAVE RIVER		Enhanced	13	4,356	2,552				1,342
FRASER RIVER		Rack	13	92,677	43,416				26,124
CAMPBELL RIVER		Enhanced	29	13	290	220	40	238	167
TOTAL				254,065	223,663	113,998	55,575	13,988	135,040
SYSTEMS ENHANCED			18	10	10	2	1	1	5

	TARGET	SOURCE	N	AVERAGE					
				1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
ISA TOTAL WILD[1]	3,235,100	Wild		1,793,597	1,412,080	1,061,717	752,740	856,908	1,169,167
ISA TOTAL WILD SERVEYED			402	173	207	190	186	201	191
ISA TOTAL ENHANCED[1]		Enhanced		254,065	223,663	113,998	55,575	13,988	135,040
ISA ENHANCED SURVEYED			18	10	10	2	1	1	5
ISA TOTAL ESCAPEMENT[1]		W&E		2,047,662	1,635,743	1,175,715	808,315	870,895	1,304,206
ISA TOTAL SURVEYED			402	173	207	190	186	201	191
SUMMER TOTAL	130,000	Wild		26023	53070	54155	13150	25929	35,410
SYSTEMS SERVEYED			2	2	2	2	2	2	2
ISC TOTAL WILD[2]	3,400,100	Wild		1,806,829	1,432,165	1,091,302	772,000	883,751	1,191,012
ISC TOTAL SYSTEMS SURVEYED			421	183	218	201	196	214	202

Note 1 Excludes Summer and Seymour/Belize chum stocks

Note 2 Includes Seymour/Belize; excludes Summer chum stocks

Table 4.2. Rank for the top 50 Inner South Coast chum salmon systems within each time period. Rank based on average total escapement for each system during each time period. Contribution of each stock to the total average escapement during the time period represented by percent and cumulative percent.

SYSTEM	AVERAGE ESCAPEMENT	PERCENT	CUMULATIVE PERCENT
1990-1997			
HARRISON RIVER	422,620	22.06	22.06
STAVE RIVER	265,795	13.88	35.94
CHILLIWACK RIVER	195,428	10.20	46.14
COWICHAN RIVER	103,750	5.42	51.56
QUALICUM RIVER	90,590	4.73	56.29
LITTLE QUALICUM RIVER	72,563	3.79	60.07
NIMPKISH RIVER	67,459	3.52	63.60
SOUTHGATE RIVER	66,875	3.49	67.09
CHEHALIS RIVER	62,338	3.25	70.34
PUNTLEDGE RIVER	62,149	3.24	73.59
NANAIMO RIVER	54,375	2.84	76.43
INDIAN RIVER	42,350	2.21	78.64
CHEAKAMUS RIVER	37,400	1.95	80.59
DESERTED RIVER	35,250	1.84	82.43
GOLDSTREAM RIVER	30,894	1.61	84.04
SQUAMISH RIVER	28,044	1.46	85.51
TZOONIE RIVER	23,875	1.25	86.75
ORFORD RIVER	22,063	1.15	87.90
SKWAWKA RIVER	15,831	0.83	88.73
ALOUETTE RIVER	15,017	0.78	89.51
CHEMAINUS RIVER	12,406	0.65	90.16
LANG CREEK	11,276	0.59	90.75
SLIAMMON CREEK	10,295	0.54	91.29
HOMATHKO RIVER	9,750	0.51	91.80
STAFFORD RIVER	6,888	0.36	92.16
MAMQUAM RIVER	6,456	0.34	92.49
CAMPBELL RIVER	6,313	0.33	92.82
INCH CREEK	5,984	0.31	93.14
KANAKA CREEK	5,094	0.27	93.40
WEAVER CREEK	4,689	0.24	93.65
VINER SOUND CREEK	4,138	0.22	93.86
AHNUHATI RIVER	3,960	0.21	94.07
UPPER PARADISE CHANNEL	3,809	0.20	94.27
SQUAWKUM CREEK	3,807	0.20	94.47
HASLAM CREEK	3,654	0.19	94.66
PEACH CREEK	3,648	0.19	94.85
LILLOOET RIVER	3,563	0.19	95.03
HEYDON CREEK	3,500	0.18	95.22
GLENDALE CREEK	3,352	0.17	95.39
KOKSILAH RIVER	2,875	0.15	95.54
ENGLISHMAN RIVER	2,756	0.14	95.69
FULMORE RIVER	2,675	0.14	95.83
TENDERFOOT CREEK	2,634	0.14	95.96
PENDER HARBOUR CREEKS	2,336	0.12	96.08
LOWER PARADISE CHANNEL	2,238	0.12	96.20
MOODY CHANNEL	2,171	0.11	96.31
HOPEDALE SLOUGH	2,125	0.11	96.43
JUDD SLOUGH	2,088	0.11	96.53
MORRISON CREEK	2,075	0.11	96.64
MAMQUAM SPAWNING CHANNEL	2,040	0.11	96.75

Table 4.2. Continued

SYSTEM	AVERAGE ESCAPEMENT	PERCENT	CUMULATIVE PERCENT
1980-1989			
CHILLIWACK RIVER	153,812	9.78	9.78
HARRISON RIVER	123,715	7.87	17.65
COWICHAN RIVER	108,000	6.87	24.52
SOUTHGATE RIVER	106,700	6.79	31.31
QUALICUM RIVER	102,890	6.54	37.85
SQUAMISH RIVER	72,027	4.58	42.43
PUNTLEDGE RIVER	64,109	4.08	46.51
LITTLE QUALICUM RIVER	54,472	3.46	49.98
CHEHALIS RIVER	53,955	3.43	53.41
STAVE RIVER	53,392	3.40	56.80
CHEAKAMUS RIVER	53,200	3.38	60.19
NANAIMO RIVER	44,140	2.81	63.00
NIMPKISH RIVER	42,365	2.69	65.69
ORFORD RIVER	42,050	2.67	68.37
WEAVER CREEK	35,575	2.26	70.63
GOLDSTREAM RIVER	27,850	1.77	72.40
VINER SOUND CREEK	25,420	1.62	74.02
INDIAN RIVER	24,950	1.59	75.60
CHEMAINUS RIVER	23,670	1.51	77.11
TZOONIE RIVER	20,965	1.33	78.44
DESERTED RIVER	20,050	1.28	79.72
ALOUETTE RIVER	18,615	1.18	80.90
HOMATHKO RIVER	14,425	0.92	81.82
SLIAMMON CREEK	13,735	0.87	82.69
HEYDON CREEK	13,570	0.86	83.56
AHNUHATI RIVER	11,020	0.70	84.26
SQUAWKUM CREEK	10,336	0.66	84.91
MAMQUAM RIVER	9,200	0.59	85.50
LILLOOET RIVER	9,200	0.59	86.09
SWELTZER RIVER	8,312	0.53	86.61
PENDER HARBOUR CREEKS	7,819	0.50	87.11
BISHOP CREEK	7,373	0.47	87.58
SKWAWKA RIVER	6,320	0.40	87.98
INCH CREEK	6,086	0.39	88.37
WAHLEACH SLOUGH	5,356	0.34	88.71
KOKSILAH RIVER	4,900	0.31	89.02
NICOMEN SLOUGH	4,447	0.28	89.30
BONELL CREEK	4,143	0.26	89.57
OKEOVER CREEK	3,941	0.25	89.82
CHILQUA CREEK	3,930	0.25	90.07
HOLLAND CREEK	3,894	0.25	90.32
CAMPBELL RIVER	3,555	0.23	90.54
AHTA RIVER	3,498	0.22	90.76
CHEF CREEK	3,265	0.21	90.97
APPLE RIVER	3,260	0.21	91.18
HASLAM CREEK	3,245	0.21	91.39
WHITTAL CREEK	3,225	0.21	91.59
BUSH CREEK	3,114	0.20	91.79
TSOLUM RIVER	3,008	0.19	91.98
STOCKING CREEK	2,888	0.18	92.16

Table 4.2. Continued

SYSTEM	AVERAGE ESCAPEMENT	PERCENT	CUMULATIVE PERCENT
1970-1979			
QUALICUM RIVER	113,250	9.21	9.21
HARRISON RIVER	108,255	8.81	18.02
CHILLIWACK RIVER	69,215	5.63	23.65
SQUAMISH RIVER	63,500	5.17	28.82
COWICHAN RIVER	63,050	5.13	33.95
LITTLE QUALICUM RIVER	53,250	4.33	38.28
ORFORD RIVER	50,625	4.12	42.40
STAVE RIVER	49,390	4.02	46.42
CHEHALIS RIVER	41,040	3.34	49.76
PUNTLEDGE RIVER	40,600	3.30	53.06
SOUTHGATE RIVER	36,200	2.95	56.01
NANAIMO RIVER	35,130	2.86	58.86
CHEAKAMUS RIVER	33,950	2.76	61.63
VINER SOUND CREEK	27,500	2.24	63.86
WEAVER CREEK	22,570	1.84	65.70
KINGCOME RIVER	22,270	1.81	67.51
HOMATHKO RIVER	20,100	1.64	69.15
MAMQUAM RIVER	19,665	1.60	70.75
HEYDON CREEK	18,825	1.53	72.28
DESERTED RIVER	18,450	1.50	73.78
INDIAN RIVER	16,350	1.33	75.11
CHEMAINUS RIVER	13,175	1.07	76.18
TZOONIE RIVER	12,870	1.05	77.23
NIMPKISH RIVER	12,700	1.03	78.26
BISHOP CREEK	11,936	0.97	79.23
AHTA RIVER	11,520	0.94	80.17
KLINAKLINI RIVER	11,500	0.94	81.11
SQUAWKUM CREEK	10,630	0.86	81.97
GLENDALE CREEK	9,730	0.79	82.76
GOLDSTREAM RIVER	7,850	0.64	83.40
PENDER HARBOUR CREEKS	7,780	0.63	84.03
APPLE RIVER	7,300	0.59	84.63
ALOUETTE RIVER	7,235	0.59	85.22
SLIAMMON CREEK	7,232	0.59	85.80
MACKENZIE SOUND CREEK	6,610	0.54	86.34
NANOOSE CREEK	6,030	0.49	86.83
SWELTZER RIVER	5,100	0.41	87.25
WAKEMAN RIVER	5,055	0.41	87.66
TSABLE RIVER	4,970	0.40	88.06
ENGLISHMAN RIVER	4,825	0.39	88.46
CAMPBELL RIVER	4,820	0.39	88.85
KOKSILAH RIVER	4,350	0.35	89.20
TOBA RIVER	4,350	0.35	89.56
PHILLIPS RIVER	4,275	0.35	89.90
INCH CREEK	4,215	0.34	90.25
KAKWEIKEN RIVER	4,120	0.34	90.58
CHEF CREEK	4,065	0.33	90.91
THEODOSIA RIVER	3,755	0.31	91.22
AHNUHATI RIVER	3,530	0.29	91.51
NORRISH CREEK	3,250	0.26	91.77

Table 4.2. Continued

SYSTEM	AVERAGE ESCAPEMENT	PERCENT	CUMULATIVE PERCENT
1960-1969			
HARRISON RIVER	87,032	10.60	10.60
CHILLIWACK RIVER	66,220	8.06	18.66
QUALICUM RIVER	55,535	6.76	25.42
COWICHAN RIVER	55,500	6.76	32.17
STAVE RIVER	45,268	5.51	37.69
LITTLE QUALICUM RIVER	42,500	5.17	42.86
PUNTLEDGE RIVER	33,400	4.07	46.93
VINER SOUND CREEK	30,640	3.73	50.66
CHEHALIS RIVER	24,916	3.03	53.69
NIMPKISH RIVER	24,250	2.95	56.64
NANAIMO RIVER	20,100	2.45	59.09
CHEAKAMUS RIVER	19,280	2.35	61.43
GLENDALE CREEK	18,858	2.30	63.73
SQUAMISH RIVER	16,750	2.04	65.77
TZOONIE RIVER	14,450	1.76	67.53
BISHOP CREEK	12,550	1.53	69.06
KINGCOME RIVER	11,200	1.36	70.42
HEYDON CREEK	10,475	1.28	71.70
AHTA RIVER	9,820	1.20	72.89
SQUAWKUM CREEK	9,681	1.18	74.07
KLINAKLINI RIVER	9,408	1.15	75.21
CHEMAINUS RIVER	9,200	1.12	76.33
TOBA RIVER	7,250	0.88	77.22
ORFORD RIVER	7,150	0.87	78.09
GOLDSTREAM RIVER	6,950	0.85	78.93
SOUTHGATE RIVER	6,650	0.81	79.74
TSABLE RIVER	6,525	0.79	80.54
DESERTED RIVER	6,100	0.74	81.28
AHNUHATI RIVER	6,000	0.73	82.01
INDIAN RIVER	5,850	0.71	82.72
THEODOSIA RIVER	5,850	0.71	83.43
KOKSILAH RIVER	5,250	0.64	84.07
QUATSE RIVER	5,065	0.62	84.69
SLIAMMON CREEK	4,810	0.59	85.28
HOLLAND CREEK	4,647	0.57	85.84
SWELTZER RIVER	3,900	0.47	86.32
ENGLISHMAN RIVER	3,575	0.44	86.75
PENDER HARBOUR CREEKS	3,455	0.42	87.17
HOMATHKO RIVER	3,260	0.40	87.57
KAKWEIKEN RIVER	3,100	0.38	87.95
WEAVER CREEK	2,940	0.36	88.30
LANG CREEK	2,815	0.34	88.65
MAMQUAM RIVER	2,780	0.34	88.99
PHILLIPS RIVER	2,605	0.32	89.30
ANGUS CREEK	2,600	0.32	89.62
LITTLE TOBA RIVER	2,598	0.32	89.94
KLITE RIVER	2,515	0.31	90.24
WAKEMAN RIVER	2,450	0.30	90.54
BUSH CREEK	2,273	0.28	90.82
BONELL CREEK	2,200	0.27	91.08

Table 4.2. Continued

SYSTEM	AVERAGE ESCAPEMENT	PERCENT	CUMULATIVE PERCENT
1953-1959			
VINER SOUND CREEK	55,000	6.13	6.13
COWICHAN RIVER	51,429	5.74	11.87
NIMPKISH RIVER	42,857	4.78	16.65
HARRISON RIVER	41,429	4.62	21.27
NANAIMO RIVER	39,643	4.42	25.69
QUALICUM RIVER	35,893	4.00	29.70
LITTLE QUALICUM RIVER	35,000	3.90	33.60
PUNTLEDGE RIVER	32,143	3.59	37.18
SQUAMISH RIVER	28,214	3.15	40.33
CHEMAINUS RIVER	23,714	2.64	42.98
CHEAKAMUS RIVER	23,500	2.62	45.60
TOBA RIVER	22,500	2.51	48.11
CHEHALIS RIVER	20,643	2.30	50.41
KLINAKLINI RIVER	17,429	1.94	52.35
THEODOSIA RIVER	17,071	1.90	54.26
HOMATHKO RIVER	16,029	1.79	56.05
AHNUHATI RIVER	15,571	1.74	57.78
INDIAN RIVER	13,571	1.51	59.30
TZOONIE RIVER	13,214	1.47	60.77
CHILLIWACK RIVER	12,414	1.38	62.15
KINGCOME RIVER	12,286	1.37	63.52
AHTA RIVER	10,929	1.22	64.74
DESERTED RIVER	10,786	1.20	65.95
KAKWEIKEN RIVER	10,557	1.18	67.12
ORFORD RIVER	10,357	1.16	68.28
QUATSE RIVER	10,143	1.13	69.41
SLIAMMON CREEK	9,643	1.08	70.49
HOLLAND CREEK	8,857	0.99	71.47
ENGLISHMAN RIVER	8,321	0.93	72.40
TSABLE RIVER	8,000	0.89	73.29
SOUTHGATE RIVER	7,429	0.83	74.12
HEYDON CREEK	7,200	0.80	74.93
GOLDSTREAM RIVER	6,857	0.76	75.69
WAKEMAN RIVER	6,857	0.76	76.46
SHOAL HARBOUR CREEK	6,000	0.67	77.12
NIMMO CREEK	5,893	0.66	77.78
BONELL CREEK	5,679	0.63	78.41
OYSTER RIVER	5,500	0.61	79.03
BISHOP CREEK	5,214	0.58	79.61
PENDER HARBOUR CREEKS	5,214	0.58	80.19
MCNAUGHTON CREEK	5,214	0.58	80.77
BUSH CREEK	4,979	0.56	81.33
GLENDALE CREEK	4,929	0.55	81.88
LANG CREEK	4,714	0.53	82.40
KEOGH RIVER	4,279	0.48	82.88
MACKENZIE SOUND CREEK	4,250	0.47	83.36
SWELTZER RIVER	4,179	0.47	83.82
STOCKING CREEK	4,071	0.45	84.28
SALMON RIVER	3,964	0.44	84.72
MARION CREEK	3,914	0.44	85.15

Table 4.2. Continued

SYSTEM	AVERAGE ESCAPEMENT	PERCENT	CUMULATIVE PERCENT
1953-1997			
HARRISON RIVER	152,466	11.86	11.86
CHILLIWACK RIVER	100,951	7.85	19.72
QUALICUM RIVER	82,366	6.41	26.12
STAVE RIVER	80,552	6.27	32.39
COWICHAN RIVER	76,789	5.97	38.36
LITTLE QUALICUM RIVER	51,727	4.02	42.39
SOUTHGATE RIVER	46,278	3.60	45.99
PUNTLEDGE RIVER	46,740	3.64	49.63
SQUAMISH RIVER	43,214	3.36	52.99
CHEHALIS RIVER	40,940	3.19	56.17
NANAIMO RIVER	37,916	2.95	59.12
NIMPKISH RIVER	36,285	2.82	61.95
CHEAKAMUS RIVER	33,956	2.64	64.59
VINER SOUND CREEK	27,860	2.17	66.75
ORFORD RIVER	27,717	2.16	68.91
INDIAN RIVER	20,118	1.57	70.48
DESERTED RIVER	17,856	1.39	71.87
TZOONIE RIVER	17,030	1.32	73.19
CHEMAINUS RIVER	16,127	1.25	74.44
GOLDSTREAM RIVER	16,037	1.25	75.69
WEAVER CREEK	14,575	1.13	76.83
HOMATHKO RIVER	12,623	0.98	77.81
HEYDON CREEK	11,269	0.88	78.69
KINGCOME RIVER	10,187	0.79	79.48
SLIAMMON CREEK	9,059	0.70	80.18
ALOUETTE RIVER	8,859	0.69	80.87
MAMQUAM RIVER	8,663	0.67	81.55
BISHOP CREEK	8,144	0.63	82.18
GLENDALE CREEK	8,133	0.63	82.81
SQUAWKUM CREEK	7,894	0.61	83.43
AHNUHATI RIVER	7,693	0.60	84.02
KLINAKLINI RIVER	7,438	0.58	84.60
AHTA RIVER	7,436	0.58	85.18
TOBA RIVER	6,562	0.51	85.69
PENDER HARBOUR CREEKS	5,460	0.42	86.12
THEODOSIA RIVER	5,350	0.42	86.53
SKWAWKA RIVER	5,219	0.41	86.94
TSABLE RIVER	4,649	0.36	87.30
SWELTZER RIVER	4,497	0.35	87.65
LANG CREEK	4,299	0.33	87.99
KOKSILAH RIVER	4,089	0.32	88.30
HOLLAND CREEK	4,054	0.32	88.62
INCH CREEK	4,032	0.31	88.93
ENGLISHMAN RIVER	4,011	0.31	89.24
KAKWEIKEN RIVER	3,885	0.30	89.55
CAMPBELL RIVER	3,493	0.27	89.82
WAKEMAN RIVER	3,298	0.26	90.08
MACKENZIE SOUND CREEK	3,246	0.25	90.33
BONELL CREEK	2,938	0.23	90.56
QUATSE RIVER	2,881	0.22	90.78

Table 4.3. Rank by wild target escapement and average escapement estimates for Inner South Coast Chum Salmon Regions. Ranked by region within each time period. Target is the total target wild escapement for each region.

	WILD ESCAPEMENT		RANK BY AVERAGE ESCAPEMENT ESTIMATES					
REGION	TARGET	RANK	1990-1997	1980-1989	1970-1979	1960-1969	1953-1959	1953-1997
FRASER RIVER	700,000	1	1	1	1	1	4	1
LOUGHBOROUGH/BUTE INLETS	437,000	2	4	3	3	6	8	4
HOWE SOUND/SUNSHINE COAST	357,500	3	6	5	4	7	9	6
BOND/KNIGHT INLETS	346,000	4	10	9	7	4	3	7
MID VANCOUVER ISLAND	230,500	5	2	2	2	2	2	2
SOUTH VANCOUVER ISLAND	214,000	6	3	4	6	5	5	5
KINGCOME INLET	195,500	7	12	12	9	12	11	11
JOHNSTONE STRAIT	190,000	8	7	8	11	8	7	9
TOBA INLET	172,000	9	15	13	13	10	10	13
SEYMOUR/BELIZE INLETS	165,000	10	11	11	10	11	12	10
JERVIS INLET	140,100	11	5	6	5	3	1	3
LOWER VANCOUVER ISLAND	134,000	12	8	7	8	9	6	8
UPPER VANCOUVER ISLAND	67,000	13	14	15	14	13	13	14
BURRARD INLET	33,000	14	9	10	12	14	14	12
BOUNDARY BAY	5,000	15	13	14	15	15	15	15

Table 4.4. Comparison of escapement estimates for selected ISC chum systems in 1997. Estimates obtained by standardized index sites and area under the curve (AUC) analysis and traditional escapement surveys (BC 16).

	Target	Estimates	
		AUC	BC 16
Seymour/ Belize Inlets			
Driftwood	20000	59	54
Jap	20000	770	400
Taaltz	45000	653	2900
Waump	18000	335	400
Bond/Knight Inlets			
Ahta	20000	1161	2080
Kakweikan	75000	383	369
Lull	100	19	15
Viner Sound	40000	221	97
Lougnborough/Bute Inlets			
Heydon	35000	3752	2500
Orford	80000	7432	2000
Quatum	300	120	70
Wortley	100	383	250
Toba Inlet			
Brem	15000	1035	361
Forbes	15000	1035	2742
Okeover	6000	5058	500
Theodosia	21000	6016	2742

Table 4.5. Chum salmon target escapements and habitat estimates based on spawning gravel estimates for selected systems in the Inner South Coast. Target escapements for non-Fraser stocks from Inner South Coast Management Plan (1986). UVI, JS, MVI, LVI, and SVI habitat estimates from Fraser et al. (1974), S/B and L/B from HRSEP Project (unpublished results 1997). Fraser River target escapement s and habitat estimates from Palmer (1972). Habitat estimates use 1.0 to 1.5 chum/sq.yd. of spawning gravel (Palmer 1972, Fraser et al. 1974).

REGION/SYSTEM	TARGET	HABITAT
SEYMOUR/BELIZE INLETS		
DRIFTWOOD CREEK	20,000	4,000
JAP CREEEK	20,000	1,000
RAINBOW CREEK	5,000	8,100
TAALTZ CREEK	45,000	4,600
WAUMP CREEK	18,000	6,400
TOTAL	88,000	20,100
UPPER VANCOUVER ISLAND		
CLUXEWE RIVER	5,000	72,800
KEOGH RIVER	15,000	20,400
QUATSE RIVER	10,000	49,000
TSULQUATE RIVER	5,000	200
TOTAL	35,000	142,400
JOHNSTONE STRAIT		
ADAM RIVER	5,000	77,100
KOKISH RIVER	5,000	20,100
NIMPKISH RIVER	110,000	99,300
SALMON RIVER	20,000	208,100
TOTAL	140,000	404,600
LOUGHBOROUGH/BUTE INLETS		
GRASSY CREEK	100	4,100
HEYDON CREEK	35,000	15,000
READ CREEK	100	5,200
WORTLEY CREEK	100	3,600
TOTAL	35,300	27,900

REGION/SYSTEM	TARGET	HABITAT
MID VANCOUVER ISLAND		
CHEF CREEK	5,000	7,700
COWIE CREEK	2,000	900
ENGLISHMAN RIVER	4,000	42,500
FRENCH CREEK	1,000	900
LITTLE QUALICUM RIVER	130,000	72,100
MCNAUGHTON CREEK	2,000	3,800
NILE CREEK	1,000	500
OYSTER RIVER	3,500	10,800
PUNTLEDGE RIVER	60,000	55,500
QUALICUM RIVER	100,000	75,000
ROSEWALL CREEK	200	8,700
TSABLE RIVER	7,000	9,500
TSOLUM RIVER	1,500	44,900
WATERLOO CREEK	2,000	1,300
WILFRED CREEK	2,500	4,600
TOTAL	321,700	338,700
LOWER VANCOUVER ISLAND		
BONELL CREEK	10,000	6,000
BONSALL CREEK	3,000	500
BUSH CREEK	10,000	4,500
HOLLAND CREEK	10,000	1,800
NANAIMO RIVER	65,000	76,600
NANOOSE CREEK	15,000	14,600
STOCKING CREEK	8,000	1,300
WALKERS CREEK	1,500	200
TOTAL	122,500	105,500
SOUTH VANCOUVER ISLAND		
CHEMAINUS RIVER	50,000	21,200
COWICHAN RIVER	110,000	158,700
GOLDSTREAM RIVER	15,000	6,500
KOKSILAH RIVER	20,000	13,300
TOTAL	195,000	199,700

REGION/SYSTEM	TARGET	HABITAT
FRASER RIVER		
CHEHALIS RIVER	200,000	44,000
HARRISION RIVER	175,000	125,840
INCH CREEK	5,000	5,500
SQUAKUM CREEK	15,000	8,800
STAVE RIVER	100,000	115,500
WEAVER CREEK	22,000	11,000
TOTAL	517,000	310,640

Table 5.1. Fraser River Wild Chum data

BY	GrossEsc	FY	TotalCpue	TotalRet	TotalFry	Ret/spawn	Ret/fry_cpue	prop3	prop4	prop5	totalprod
1959	152300.00	1960		390406.74		2.56		0.45	0.54	0.02	147902.22
1960	144782.00	1961		400116.37		2.76		0.32	0.67	0.01	161876.23
1961	103945.00	1962		156512.52		1.51		0.35	0.62	0.03	253407.35
1962	130357.00	1963		315789.99		2.42		0.18	0.81	0.01	136773.53
1963	192245.00	1964		151652.27		0.79		0.27	0.70	0.03	316579.63
1964	246741.00	1965	1259.93	1063848.75		4.31	844.37	0.17	0.81	0.02	388414.91
1965	129484.00	1966	809.46	491327.14	18693.00	3.79	606.98	0.37	0.62	0.01	546850.18
1966	360835.00	1967	1459.83	1009655.46	33302.00	2.80	691.63	0.28	0.68	0.04	330561.36
1967	213873.00	1968	1074.19	268774.16	23764.00	1.26	250.21	0.21	0.69	0.10	270694.00
1968	670528.00	1969	1450.17	1865063.01	31631.00	2.78	1284.45	0.08	0.71	0.21	204470.82
1969	309245.00	1970	1968.75	1880298.93	42825.00	6.08	955.07	0.05	0.85	0.09	435616.75
1970	284275.00	1971		435789.36		1.53		0.11	0.85	0.04	310694.69
1971	290150.00	1972	707.70	385428.82	16467.00	1.33	544.62	0.38	0.58	0.04	358080.80
1972	423290.00	1973	2397.64	1174026.53	53201.00	2.77	489.66	0.24	0.74	0.01	131410.70
1973	267105.00	1974	1278.73	736699.04	30695.00	2.76	576.12	0.22	0.74	0.04	436420.73
1974	350390.00	1975	1835.45	1446851.74	40241.00	4.13	788.28	0.13	0.84	0.03	429166.11
1975	191445.00	1976	466.84	344975.01	10381.00	1.80	738.95	0.60	0.38	0.02	509728.09
1976	340542.00	1977	2308.98	902606.00	51711.00	2.65	390.91	0.14	0.82	0.04	238195.07
1977	599366.00	1978	1162.72	755062.82	26992.00	1.26	649.19	0.40	0.53	0.07	316650.27
1978	359065.00	1979	776.44	641220.95	16660.00	1.78	824.65	0.11	0.71	0.18	409191.32
1979	255634.00	1980	858.72	391157.45	19809.00	1.53	455.51	0.31	0.63	0.05	350816.58
1980	312141.00	1981	1413.28	329015.65	32004.50	1.05	232.80	0.24	0.64	0.12	392560.29
1981	435316.00	1982	2751.97	1352521.98	60424.00	3.11	491.45	0.17	0.74	0.08	598875.06
1982	320291.00	1983	3464.42	1799067.18	81042.00	5.62	519.30	0.34	0.63	0.03	1240133.21
1983	364991.00	1984	1651.47	629936.19	36811.00	1.72	379.25	0.27	0.52	0.20	877449.80
1984	433266.00	1985	1821.78	987083.92	41938.50	2.28	541.12	0.05	0.75	0.20	527084.66
1985	1295255.00	1986	1440.89	702251.53	34259.00	0.54	486.21	0.09	0.77	0.13	604650.49
1986	972927.00	1987	2736.50	2040923.63	58830.50	2.09	743.71	0.06	0.72	0.22	641755.86
1987	398343.00	1988	1855.70	612835.12	36477.50	1.52	327.19	0.03	0.83	0.13	794029.47
1988	585317.00	1989	1785.24	1283717.79	38822.00	2.16	709.18	0.11	0.65	0.23	742804.53
1989	585552.00	1990	1048.70	1355336.57	19862.00	2.28	1270.49	0.03	0.60	0.36	567255.16
1990	988875.00	1991	1748.00	1645552.03	39898.50	1.66	937.78	0.03	0.74	0.23	862505.73
1991	859274.00	1992	1255.91	1286122.43	47688.50	1.50	1023.67	0.14	0.80	0.06	219292.71
1992	741618.00	1993	1840.76	988585.03	42907.00	1.33	537.05	0.37	0.60	0.03	
1993	809578.00	1994	487.03	759383.22	19971.00	0.94	1559.22	0.27	0.73	0.00	

1994	1498436.00	1995	2696.85	93299.59	59815.50	0.06	34.60	1.00	0.00	0.00
1995	1673067.00	1996	1124.67	0.00	22915.50	0.00	0.00			
1996	867582	1997		0		0				
1997	656946	1998		0		0				
1998	2600000	1999		0						

Table 5.2 Production of all wild chum salmon from the Study Area including Fraser River and non-Fraser River stocks.

				Age Composition			Brood Return				Percent Return at		
Year	Escapement	Catch	Total Return	Age3	Age4	Age5	Age3	Age4	Age5	Total Brood	Age3	Age4	Age5
1953	939,750	2,342,945	3,282,695				-	-	28,737	28,737	0.0%	0.0%	100.0%
1954	1,074,575	3,006,207	4,080,782				-	1,602,068	52,657	1,654,725	0.0%	96.8%	3.2%
1955	605,950	717,079	1,323,029				843,956	1,412,919	13,650	2,270,525	37.2%	62.2%	0.6%
1956	472,826	648,516	1,121,342				654,368	762,565	24,812	1,441,745	45.4%	52.9%	1.7%
1957	1,005,305	532,022	1,537,327				549,109	820,260	20,603	1,389,973	39.5%	59.0%	1.5%
1958	1,127,425	1,347,335	2,474,760	34.1%	64.7%	1.2%	114,688	204,981	17,412	337,081	34.0%	60.8%	5.2%
1959	908,275	1,211,669	2,119,944	30.9%	66.6%	2.5%	688,383	594,380	19,273	1,302,036	52.9%	45.7%	1.5%
1960	626,002	699,323	1,325,325	41.4%	57.5%	1.0%	360,008	801,168	9,209	1,170,385	30.8%	68.5%	0.8%
1961	580,349	379,411	959,760	11.9%	85.5%	2.6%	161,879	241,266	10,262	413,407	39.2%	58.4%	2.5%
1962	624,825	289,143	913,968	75.3%	22.4%	2.3%	139,239	611,803	10,550	761,592	18.3%	80.3%	1.4%
1963	631,701	331,393	963,094	37.4%	61.7%	1.8%	98,842	293,071	10,298	402,211	24.6%	72.9%	2.6%
1964	777,783	198,103	975,886	15.9%	82.1%	2.0%	504,276	1,796,457	50,861	2,351,594	21.4%	76.4%	2.2%
1965	327,196	62,518	389,714	35.7%	61.9%	2.4%	382,879	724,234	13,526	1,120,640	34.2%	64.6%	1.2%
1966	880,817	93,923	974,740	10.1%	62.8%	1.1%	669,042	1,841,316	80,833	2,591,190	25.8%	71.1%	3.1%
1967	674,940	167,743	842,683	59.8%	34.8%	1.3%	150,653	359,164	72,947	582,765	25.9%	61.6%	12.5%
1968	1,601,617	728,231	2,329,848	16.4%	77.1%	0.4%	298,187	3,561,127	827,267	4,686,580	6.4%	76.0%	17.7%
1969	913,334	553,128	1,466,462	45.6%	49.4%	3.5%	266,643	3,395,967	442,132	4,104,742	6.5%	82.7%	10.8%
1970	1,031,031	974,764	2,005,795	7.5%	91.8%	0.7%	101,206	946,586	35,001	1,082,793	9.3%	87.4%	3.2%
1971	572,296	165,888	738,184	40.4%	48.7%	11.0%	373,020	470,880	31,181	875,081	42.6%	53.8%	3.6%
1972	1,765,522	2,136,895	3,902,417	6.9%	91.3%	1.9%	604,474	1,684,796	31,396	2,320,667	26.0%	72.6%	1.4%
1973	1,428,407	2,894,034	4,322,441	2.3%	78.5%	19.1%	314,984	1,149,863	56,881	1,521,728	20.7%	75.6%	3.7%
1974	1,147,371	620,476	1,767,847	21.1%	53.9%	25.0%	394,831	2,338,218	97,232	2,830,282	14.0%	82.6%	3.4%
1975	562,907	547,449	1,110,356	54.4%	42.4%	3.2%	395,247	301,396	16,242	712,884	55.4%	42.3%	2.3%
1976	871,498	1,159,464	2,030,962	15.5%	83.0%	1.5%	284,811	1,657,179	94,346	2,036,336	14.0%	81.4%	4.6%
1977	1,353,794	222,316	1,576,110	25.1%	73.0%	2.0%	677,150	1,108,655	204,774	1,990,579	34.0%	55.7%	10.3%
1978	1,313,647	1,476,679	2,790,326	14.2%	83.8%	2.0%	192,912	1,802,149	321,254	2,316,315	8.3%	77.8%	13.9%
1979	627,637	93,965	721,602	39.5%	41.8%	13.5%	487,913	679,941	72,036	1,239,890	39.4%	54.8%	5.8%
1980	1,274,157	1,076,413	2,350,570	28.8%	70.5%	0.7%	215,604	707,251	90,769	1,013,623	21.3%	69.8%	9.0%
1981	1,253,118	142,796	1,395,914	13.8%	79.4%	6.8%	793,072	2,270,766	264,812	3,328,650	23.8%	68.2%	8.0%
1982	1,235,989	1,285,512	2,521,501	19.4%	71.5%	8.1%	1,396,594	2,636,813	191,996	4,225,403	33.1%	62.4%	4.5%
1983	1,024,844	192,599	1,217,443	17.7%	55.8%	26.4%	396,791	1,124,910	396,481	1,918,183	20.7%	58.6%	20.7%
1984	1,454,932	120,551	1,575,483	50.3%	44.9%	4.8%	160,092	2,294,481	358,681	2,813,254	5.7%	81.6%	12.7%
1985	2,603,153	1,154,975	3,758,128	37.2%	60.4%	2.4%	197,872	952,910	190,183	1,340,965	14.8%	71.3%	14.1%
1986	1,824,021	1,474,395	3,298,416	12.0%	79.9%	8.0%	206,599	2,948,162	1,056,378	4,211,139	4.9%	70.0%	25.1%
1987	1,117,826	367,656	1,485,482	10.8%	75.7%	12.9%	38,051	1,184,721	217,408	1,440,180	2.6%	82.3%	15.1%
1988	1,440,289	1,450,559	2,890,848	6.8%	79.4%	13.7%	335,789	2,222,487	832,962	3,391,238	9.9%	65.5%	24.6%
1989	874,797	680,473	1,555,270	13.2%	61.5%	22.9%	103,324	2,325,686	1,045,479	3,474,489	3.0%	66.9%	30.1%
1990	1,593,336	1,585,638	3,178,974	1.2%	92.7%	6.0%	148,510	2,617,604	536,074	3,302,188	4.5%	79.3%	16.2%
1991	1,798,272	801,800	2,600,072	12.9%	45.6%	40.6%	394,378	1,466,764	132,150	1,993,293	19.8%	73.6%	6.6%
1992	1,927,215	1,197,671	3,124,886	3.3%	71.1%	7.0%	517,126	1,061,713	73,226	1,652,065	31.3%	64.3%	4.4%
1993	1,872,917	1,467,088	3,340,005	4.4%	69.6%	24.9%	-	-	-	-	-	-	-
1994	2,500,740	1,594,867	4,095,607	9.6%	63.9%	25.5%	-	-	-	-	-	-	-
1995	1,958,886	593,824	2,552,710	20.3%	57.5%	21.0%	-	-	-	-	-	-	-
1996	1,243,465	329,599	1,573,064	23.4%	67.5%	8.4%	-	-	-	-	-	-	-
1997	1,136,778	413,930	1,550,708	13.7%	81.5%	4.7%	-	-	-	-	-	-	-
1998	-	2,042,679	2,042,679	12.2%	82.8%	4.9%	-	-	-	-	-	-	-

Table 5.3 Comparison of Stock Recruitment Parameters

	ALL DATA WILD	BEACHAMS TECH REP NO. 1270	JOYCE&CASS PSARC 92-02	CURRENT FRASER RIVER DATA
a'	1.01	0.48	1.06	1.07
b'	2,659,444	6,190,000	1,139,785	1,737,787
Umsy	0.44	0.22	0.45	0.46
Smax =	2,620,950	12,896,000	1,075,269	1,623,566
Rmax =	2,659,830	7,667,000	1,141,760	1,741,900
Smsy =	1,140,863	2,887,000	485,320	738,690
Rmsy =	2,036,482	3,730,000	891,996	1,366,832
Harv.Surp =	895,619	843,000	406,675	628,141

Table 6.1 Results of Heuristic Prediction of Total Returns

	Regression Parameters					
Brood Year	b0	b1	Fry Cpue	Predicted Total Returns	Total Returns	Percent Difference
1986	101,897	540	2,380	1,387,389	2,040,924	32.02%
1987	96,570	530	2,900	1,633,978	612,835	-166.63%
1988	101,189	534	2,890	1,642,806	1,283,718	-27.97%
1989	176,592	504	2,441	1,405,645	1,355,337	-3.71%
1990	188,019	511	2,992	1,715,716	1,645,552	-4.26%
1991	223,635	499	3,187	1,813,134	1,286,122	-40.98%
1992	222,872	496	3,173	1,796,345	988,585	-81.71%

METHOD	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	MPE	MAPE
1) PRE- AND EARLY SEASON												
PRE-SEASON	29.5%	91.0%	-17.0%	31.2%	-1.7%	-37.3%	5.0%	172.9%	242.9%	259.0%	77.6%	88.8%
TEST FISHING												
Test Fishing Week 9/4	-45.5%	60.4%	2.8%	27.9%	-18.7%	-50.6%	-2.9%	15.0%	133.9%	33.5%	15.6%	39.1%
COMMERCIAL FISHERY												
Commercial Week 9/4 Total Catch	-15.6%	64.7%	-3.9%	8.2%	4.2%	-45.5%	-10.3%	22.4%	60.5%		9.4%	26.2%
Commercial Week 9/4 Seine Catch	-3.6%	87.0%	3.1%	13.4%	8.0%	-44.9%	-11.8%	-30.7%	74.6%	50.0%	10.6%	32.7%
Comercial Week 9/4 Seine CPE	-18.1%	56.5%	-15.5%	-0.1%	8.0%	-46.7%	-24.5%	32.3%	133.9%	33.5%	14.0%	36.9%
WEIGHTED												
Test Fishing CPE Week 9/4 & Total Commercial Fishery Total Catch Week 9/4	-27.2%	63.1%	-0.8%	23.8%	-5.3%	-47.3%	-7.1%	18.7%	70.1%		9.8%	29.3%
Test Fishing CPE Week 9/4 & Total Commercial Fishery Seine Catch Week 9/4	-20.1%	76.5%	3.0%	27.3%	-3.2%	-46.8%	-7.8%	-8.5%	77.9%	31.9%	13.0%	30.3%
Test Fishing CPE Week 9/4 & Total Commercial Fishery Seine CPE Week 9/4	-31.3%	58.4%	-8.2%	19.6%	-14.0%	-48.3%	-13.3%	22.8%	107.4%	39.4%	13.2%	36.3%
2) MID-SEASON												
TEST FISHING												
Test Fishing Week 9/4 To 10/2	-33.2%	71.3%	12.3%	8.5%	-19.4%	-25.3%	28.1%	62.1%	78.8%	67.1%	25.0%	40.6%
COMMERCIAL FISHERY												
Commercial Week 10/2 Total Catch			53.4%		-2.6%		7.9%				19.6%	21.3%
Commercial Week 10/2 Seine Catch			40.8%		1.9%		5.6%				16.1%	16.1%
Comercial Week 10/2 Seine CPE			11.8%		-9.8%		13.9%				5.3%	11.8%
WEIGHTED												
Test Fishing CPE Week 9/4 To 10/2 & Total Commercial Fishery Total Catch Week 10/2			35.0%		-13.7%		17.9%				13.1%	22.2%
Test Fishing CPE Week 9/4 To 10/2 & Total Commercial Fishery Seine Catch Week 10/2			27.3%		-7.6%		15.9%				11.9%	16.9%
Test Fishing CPE Week 9/4 To 10/2 & Total Commercial Fishery Seine CPE Week 10/2			12.0%		20.2%		19.7%				17.3%	17.3%
3) END OF SEASON												
TEST FISHING												
Test Fishing Week 9/4 To 10/3	2.1%	57.9%	9.5%	4.5%	-12.6%	-18.6%	41.2%	59.4%	123.2%	86.2%	35.3%	41.5%
COMMERCIAL FISHERY												
Commercial Week 10/4 Total Catch	37.7%	50.7%	12.6%		10.1%	10.7%	-25.1%				16.1%	24.5%
Commercial Week 10/4 Seine Catch	58.1%	75.9%	9.3%		1.1%	16.3%	-17.4%				23.9%	29.7%
Comercial Week 10/4 Seine CPE	18.4%	53.4%	-0.1%		9.1%	24.0%	-14.7%				15.0%	20.0%
WEIGHTED												
Test Fishing CPE Week 9/4 To 10/3 & Total Commercial Fishery Total Catch Week 10/4	17.0%	54.5%	10.8%		-3.4%	-5.1%	26.2%				16.7%	19.5%
Test Fishing CPE Week 9/4 To 10/3 & Total Commercial Fishery Seine Catch Week 10/4	30.0%	67.1%	9.4%		-6.8%	-3.1%	23.7%				20.1%	23.4%
Test Fishing CPE Week 9/4 To 10/3 & Total Commercial Fishery Seine CPE Week 10/4	8.7%	55.1%	4.7%		-3.2%	3.6%	26.4%				15.9%	17.0%

Table 7.1. Performance of various models for estimating run size to Clockwork chum stocks (1988-1997) at three stages of the return migration. MPE = mean percent error and MAPE = mean absolute percent error.

METHOD	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1) PRE- AND EARLY SEASON										
PRE-SEASON	4,089,000	3,329,000	2,929,000	3,279,000	4,111,000	2,657,000	4,205,000	4,187,000	4,197,000	4,965,000
TEST FISHING										
Test Fishing Week 9/4	1,722,000	2,796,000	3,628,000	3,196,000	3,399,000	2,092,000	3,889,000	1,764,000	2,863,000	1,846,000
COMMERCIAL FISHERY										
Commercial Week 9/4 Total Catch	2,663,000	2,871,000	3,389,000	2,704,000	4,360,000	2,308,000	3,592,000	1,877,000	1,965,000	
Commercial Week 9/4 Seine Catch	3,044,000	3,259,000	3,639,000	2,833,000	4,517,000	2,335,000	3,533,000	1,063,000	2,137,000	2,075,000
Comercial Week 9/4 Seine CPE	2,586,000	2,727,000	2,981,000	2,496,000	4,517,000	2,258,000	3,024,000	2,030,000	2,863,000	1,846,000
WEIGHTED										
Test Fishing CPE Week 9/4 & Total Commercial Fishery Total Catch Week 9/4	2,297,000	2,842,000	3,500,000	3,094,000	3,963,000	2,233,000	3,722,000	1,821,000	2,082,000	
Test Fishing CPE Week 9/4 & Total Commercial Fishery Seine Catch Week 9/4	2,522,000	3,076,000	3,634,000	3,181,000	4,050,000	2,252,000	3,694,000	1,403,000	2,177,000	1,824,000
Test Fishing CPE Week 9/4 & Total Commercial Fishery Seine CPE Week 9/4	2,170,000	2,761,000	3,239,000	2,988,000	3,596,000	2,188,000	3,472,000	1,883,000	2,538,000	1,928,000
2) MID-SEASON										
TEST FISHING										
Test Fishing Week 9/4 To 10/2	2,109,000	2,985,000	3,962,000	2,712,000	3,373,000	3,163,000	5,129,000	2,486,000	2,189,000	2,311,000
COMMERCIAL FISHERY										
Commercial Week 10/2 Total Catch			5,411,000		4,076,000		4,320,000			
Commercial Week 10/2 Seine Catch			4,967,000		4,264,000		4,231,000			
Comercial Week 10/2 Seine CPE			3,944,000		3,772,000		4,561,000			
WEIGHTED										
Test Fishing CPE Week 9/4 To 10/2 & Total Commercial Fishery Total Catch Week 10/2			4,762,000		3,608,000		4,723,000			
Test Fishing CPE Week 9/4 To 10/2 & Total Commercial Fishery Seine Catch Week 10/2			4,492,000		3,865,000		4,640,000			
Test Fishing CPE Week 9/4 To 10/2 & Total Commercial Fishery Seine CPE Week 10/2			3,951,000		5,030,000		4,792,000			
3) END OF SEASON										
TEST FISHING										
Test Fishing Week 9/4 To 10/3	3,222,000	2,753,000	3,862,000	2,612,000	3,655,000	3,446,000	5,654,000	2,445,000	2,732,000	2,575,000
COMMERCIAL FISHERY										
Commercial Week 10/4 Total Catch	4,346,000	2,627,000	3,974,000		4,606,000	4,689,000	3,000,000			
Commercial Week 10/4 Seine Catch	4,991,000	3,066,000	3,856,000		4,227,000	4,927,000	3,310,000			
Comercial Week 10/4 Seine CPE	3,739,000	2,674,000	3,525,000		4,564,000	5,254,000	3,415,000			
WEIGHTED										
Test Fishing CPE Week 9/4 To 10/3 & Total Commercial Fishery Total Catch Week 10/4	3,693,000	2,693,000	3,909,000		4,041,000	4,021,000	5,056,000			
Test Fishing CPE Week 9/4 To 10/3 & Total Commercial Fishery Seine Catch Week 10/4	4,104,000	2,912,000	3,860,000		3,900,000	4,104,000	4,956,000			
Test Fishing CPE Week 9/4 To 10/3 & Total Commercial Fishery Seine CPE Week 10/4	3,432,000	2,704,000	3,693,000		4,048,000	4,389,000	5,064,000			
ACTUAL RUN SIZE	3,157,000	1,743,000	3,528,000	2,499,000	4,183,000	4,236,000	4,005,000	1,534,000	1,224,000	1,383,000

Table 7.2. Comparison of estimated run size for different run size models to the actual run size for Clockwork chum salmon.

Table 8.1: Estimated model parameters (standard error in parentheses) for data from 1968 to 1996

Stock	**ARIMA (p,d,q)**	**ϕ**	**θ**	**μ**	**β**	**σ_ε^2**	**AIC**
Fraser River	(0,0,0)	NA	NA	0.795 (0.115)	0.478 (0.166)	0.200	37.613
	(1,0,0)	0.132 (0.198)	NA	0.805 (0.133)	0.455 (0.191)	0.204	39.048
	(0,0,1)	NA	-0.170 (0.199)	0.806 (0.134)	0.452 (0.193)	0.203	38.885
Non-Fraser River	(0,0,0)	NA	NA	1.272 (0.155)	-0.178 (0.223)	0.361	54.723
	(1,0,0)	-0.015 (0.201)	NA	1.272 (0.157)	-0.183 (0.227)	0.379	56.978
	(0,0,1)	NA	0.024 (0.201)	1.271 (0.155)	-0.182 (0.225)	0.378	56.953
Total	(0,0,0)	NA	NA	2.067 (0.245)	0.300 (0.353)	0.903	81.324
	(1,0,0)	-0.042 (0.200)	NA	2.063 (0.241)	0.304 (0.348)	0.944	83.454
	(0,0,1)	NA	0.075 (0.199)	2.059 (0.233)	0.313 (0.337)	0.942	83.417

Table 8.2: Estimated model parameters (standard error in parentheses) for data from 1974 to 1996.

Stock	**ARIMA (p,d,q)**	ϕ	θ	μ	β	σ_ε^2	**AIC**
Fraser River	(0,0,0)	NA	NA	0.712 (0.150)	0.561 (0.193)	0.203	30.649
	(1,0,0)	0.119 (0.226)	NA	0.725 (0.171)	0.536 (0.218)	0.211	32.240
	(0,0,1)	NA	-0.134(0.229)	0.724 (0.171)	0.537 (0.219)	0.210	32.195
Non-Fraser River	(0,0,0)	NA	NA	1.093 (0.153)	0.001 (0.195)	0.209	31.287
	(1,0,0)	-0.259 (0.226)	NA	1.074 (0.124)	0.035 (0.161)	0.210	32.257
	(0,0,1)	NA	0.436 (0.228)	1.069 (0.093)	0.062 (0.125)	0.205	31.788
Total	(0,0,0)	NA	NA	1.805 (0.263)	0.562 (0.337)	0.623	56.409
	(1,0,0)	-0.243 (0.225)	NA	1.772 (0.216)	0.622 (0.279)	0.626	57.379
	(0,0,1)	NA	0.396 (0.207)	1.749 (0.167)	0.672 (0.217)	0.607	56.735

Appendix 1 Contribution of Inner South Coast enhanced stocks by brood year by age by facility to catch and escapement.

Non Fraser Enhanced Stocks (Puntledge, Big & Little Qualicum)

	Catch at Age						Escapement at Age						Catch + Escapement at Age					
Br.Yr.	2	3	4	5	6	Total	2	3	4	5	6	Total	2	3	4	5	6	Total
1977	0	35,304	38,671	6,906	0	80,881	0	34,801	74,168	4,632	0	113,601	0	70,105	112,839	11,538	0	194,482
1978	0	6,270	151,703	12,500	0	170,472	0	12,026	101,750	13,466	0	127,242	0	18,296	253,453	25,966	0	297,714
1979	0	56,729	88,608	14,866	0	160,204	0	48,423	140,987	7,281	0	196,691	0	105,152	229,595	22,147	0	356,895
1980	0	10,682	69,072	3,505	0	83,259	0	25,882	49,777	0	0	75,659	0	36,564	118,849	3,505	0	158,918
1981	0	93,376	311,081	19,086	0	423,543	0	86,426	102,217	5,427	0	194,070	0	179,802	413,298	24,513	0	617,613
1982	0	271,623	511,376	35,493	2,149	820,641	0	171,802	267,527	34,683	1,887	475,899	0	443,425	778,903	70,176	4,036	1,296,540
1983	0	55,819	233,651	55,121	1,432	346,023	0	16,307	105,241	27,290	222	149,060	0	72,126	338,892	82,411	1,654	495,083
1984	0	8,394	132,885	35,196	92	176,567	0	2,830	102,892	27,621	0	133,343	0	11,224	235,777	62,817	92	309,910
1985	0	8,828	81,152	7,853	0	97,833	0	4,445	55,863	7,110	1	67,419	0	13,273	137,015	14,963	1	165,252
1986	0	29,207	304,537	142,029	4,933	480,706	0	21,819	143,212	38,203	337	203,571	0	51,026	447,749	180,232	5,270	684,277
1987	0	3,369	135,439	83,188	2,022	224,019	0	1,407	81,221	9,365	0	91,993	0	4,776	216,660	92,553	2,022	316,012
1988	0	12,066	953,690	303,100	15,210	1,284,066	0	37,465	185,074	111,593	2,832	336,964	0	49,531	1,138,764	414,693	18,042	1,621,030
1989	0	19,500	426,001	109,566	0	555,067	0	6,612	193,305	48,886	328	249,131	0	26,112	619,306	158,452	328	804,199
1990	0	34,022	394,147	20,232	0	448,402	0	12,508	231,625	42,738	185	287,056	0	46,530	625,772	62,970	185	735,458
1991	0	37,736	19,998	0	0	57,734	0	28,013	52,292	4,383	0	84,688	0	65,749	72,291	4,383	0	142,422
1992	0	3,581	0	0	0	3,581	0	9,677	26,049	0	0	35,726	0	13,257	26,049	0	0	39,307
1993	0	2,169	0	0	0	2,169	0	37,849	0	0	0	37,849	0	40,018	0	0	0	40,018
Total	0	688,675	3,852,012	848,642	25,838	5,415,166	0	558,292	1,913,201	382,677	5,793	2,859,962	0	1,246,967	5,765,212	1,231,319	31,630	8,275,128
Tot.77-91	0	682,925	3,852,012	848,642	25,838	5,409,417	0	510,766	1,887,151	382,677	5,793	2,786,387	0	1,193,691	5,739,163	1,231,319	31,630	8,195,804

Appendix 1 (con't) Contribution of Inner South Coast enhanced stocks by brood year by age by facility to catch and escapement.

Fraser Enhanced Stocks (Chilliwack, Chehalis, Blaney, Inch, Stave)

	Catch at Age						Escapement at Age						Catch + Escapement at Age					
Br.Yr.	2	3	4	5	6	Total	2	3	4	5	6	Total	2	3	4	5	6	Total
1977	0	2,766	310	356	0	3,433	2	2,492	4,017	353	0	6,864	2	5,258	4,327	709	0	10,297
1978	0	1	1,167	5	0	1,173	0	1,167	3,143	90	0	4,400	0	1,168	4,310	95	0	5,573
1979	0	707	57	0	0	765	0	3,358	2,546	59	0	5,963	0	4,065	2,603	59	0	6,728
1980	0	0	1,864	0	0	1,864	0	3,248	1,954	37	0	5,239	0	3,248	3,818	37	0	7,103
1981	0	1,829	9,696	5,050	0	16,575	0	7,675	44,387	1,733	0	53,795	0	9,504	54,083	6,783	0	70,370
1982	0	18,282	116,758	3,268	250	138,559	0	112,602	211,215	14,551	106	338,474	0	130,884	327,973	17,819	356	477,033
1983	0	3,800	3,798	4,136	13	11,748	0	6,492	51,191	4,907	0	62,590	0	10,292	54,989	9,043	13	74,338
1984	0	867	162,527	12,357	146	175,897	0	15,468	104,686	10,227	119	130,500	0	16,335	267,213	22,584	265	306,397
1985	0	44,488	67,799	3,451	0	115,737	0	54,553	169,961	5,562	0	230,076	0	99,041	237,760	9,013	0	345,813
1986	0	12,982	140,953	17,252	129	171,315	0	45,261	202,872	65,560	640	314,333	0	58,243	343,825	82,812	769	485,648
1987	0	2,004	23,336	12,247	0	37,588	0	1,735	87,549	11,410	78	100,772	0	3,739	110,885	23,657	78	138,360
1988	0	876	104,660	15,648	138	121,322	0	33,769	139,169	18,558	320	191,816	0	34,645	243,829	34,206	458	313,138
1989	0	13,442	110,879	15,663	196	140,180	0	30,749	232,972	20,168	121	284,010	0	44,191	343,851	35,831	318	424,190
1990	0	13,821	90,813	9,186	0	113,820	0	20,071	136,770	28,484	260	185,585	0	33,892	227,583	37,670	260	299,405
1991	0	15,302	25,407	548	0	41,257	0	16,493	61,988	9,561	0	88,042	0	31,795	87,395	10,109	0	129,299
1992	0	3,093	2,381	0	0	5,475	0	10,430	40,675	0	0	51,105	0	13,523	43,057	0	0	56,580
1993	0	1,220	0	0	0	1,220	0	84,396	0	0	0	84,396	0	85,616	0	0	0	85,616
Total	0	135,481	862,406	99,167	873	1,097,927	2	449,959	1,495,095	191,261	1,644	2,137,960	2	585,439	2,357,501	290,427	2,517	3,235,887
Tot.77-91	0	131,167	860,025	99,167	873	1,091,232	2	355,133	1,454,420	191,261	1,644	2,002,459	2	486,300	2,314,445	290,427	2,517	3,093,691

Appendix 1 (con't) Contribution of Inner South Coast enhanced stocks by brood year by age by facility to catch and escapement.

Inner South Coast Enhanced Stocks (Puntledge, Big & Little Qualicum, Chilliwack, Chehalis, Blaney, Inch, Stave)

	Catch at Age						Escapement at Age						Catch + Escapement at Age					
Br.Yr.	2	3	4	5	6	Total	2	3	4	5	6	Total	2	3	4	5	6	Total
1977	0	38,070	38,982	7,262	0	84,314	2	37,293	78,185	4,985	0	120,465	2	75,363	117,167	12,247	0	204,779
1978	0	6,271	152,869	12,505	0	171,645	0	13,193	104,893	13,556	0	131,642	0	19,464	257,762	26,061	0	303,287
1979	0	57,436	88,666	14,866	0	160,968	0	51,781	143,533	7,340	0	202,654	0	109,217	232,199	22,206	0	363,622
1980	0	10,682	70,936	3,505	0	85,123	0	29,130	51,731	37	0	80,898	0	39,812	122,667	3,542	0	166,021
1981	0	95,205	320,777	24,136	0	440,119	0	94,101	146,604	7,160	0	247,865	0	189,306	467,381	31,296	0	687,984
1982	0	289,904	628,134	38,762	2,399	959,199	0	284,404	478,742	49,234	1,993	814,373	0	574,308	1,106,876	87,996	4,392	1,773,572
1983	0	59,619	237,450	59,258	1,445	357,772	0	22,799	156,432	32,197	222	211,650	0	82,418	393,882	91,455	1,667	569,422
1984	0	9,261	295,411	47,553	238	352,464	0	18,298	207,578	37,848	119	263,843	0	27,559	502,989	85,401	357	616,307
1985	0	53,315	146,951	11,304	0	213,570	0	58,998	225,824	12,672	1	297,495	0	112,313	374,775	23,976	1	511,065
1986	0	42,189	445,490	159,281	5,062	652,021	0	67,080	346,084	103,763	977	517,904	0	109,269	791,574	263,044	6,039	1,169,925
1987	0	5,374	158,775	95,436	2,022	261,606	0	3,142	168,770	20,775	78	192,765	0	8,516	327,545	116,211	2,100	454,371
1988	0	12,941	1,058,351	318,748	15,348	1,405,388	0	71,234	324,243	130,151	3,152	528,780	0	84,175	1,382,594	448,899	18,500	1,934,168
1989	0	32,941	536,880	125,229	196	695,247	0	37,361	426,277	69,054	450	533,142	0	70,302	963,157	194,283	646	1,228,389
1990	0	47,844	484,960	29,418	0	562,222	0	32,579	368,395	71,222	445	472,641	0	80,423	853,355	100,640	445	1,034,863
1991	0	53,038	45,405	548	0	98,992	0	44,506	114,280	13,944	0	172,730	0	97,544	159,685	14,492	0	271,721
1992	0	6,674	2,381	0	0	9,056	0	20,106	66,724	0	0	86,831	0	26,780	69,106	0	0	95,886
1993	0	3,389	0	0	0	3,389	0	122,245	0	0	0	122,245	0	125,634	0	0	0	125,634
Total	0	824,156	4,714,418	947,809	26,711	6,513,093	2	1,008,250	3,408,295	573,938	7,437	4,997,922	2	1,832,406	8,122,714	1,521,747	34,147	11,511,015
Tot.77-91	0	814,093	4,712,037	947,809	26,711	6,500,649	2	865,899	3,341,571	573,938	7,437	4,788,846	2	1,679,992	8,053,608	1,521,747	34,147	11,289,495

Appendix 2. 80% and 95% Bootstrap Confidence limits for Ricker Parameters.

```
Bootstrap statistics for Fraser River chum salmon

Variable  | Reps  Observed     Bias      Std. Err.    [80% Conf. Interval]
---------+-----------------------------------------------------------
OptimalH |  1000  .4549801  -.0121472  .0623524   .3750194  .5349408  (N)
         |                                        .3616587  .5189448  (P)
         |                                        .3857566  .5349245 (BC)
---------+-----------------------------------------------------------
rickera  |  1000  1.070352  -.0283757  .1755477   .8452293  1.295474  (N)
         |                                        .8166965  1.260237  (P)
         |                                        .8799061  1.310163 (BC)
---------+-----------------------------------------------------------
rickerb  |  1000   1737787  -199911.8  2.83e+07  -3.45e+07  3.80e+07  (N)
         |                                         1120830   4803063  (P)
         |                                         1154187   5634560 (BC)
---------+-----------------------------------------------------------
    Smsy |  1000  738690.3  -87299.45  1.24e+07  -1.52e+07  1.66e+07  (N)
         |                                        459301.6   2092178  (P)
         |                                          479080   2481638 (BC)
---------+-----------------------------------------------------------
    Smax |  1000   1623566  -212837.3  3.22e+07  -3.97e+07  4.29e+07  (N)
         |                                        853276.8   5201239  (P)
         |                                        913186.5   6304125 (BC)
---------+-----------------------------------------------------------
    Rmax |  1000   1741900  -195009.9  2.85e+07  -3.48e+07  3.83e+07  (N)
         |                                         1140995   4825827  (P)
         |                                         1168168   5227287 (BC)
---------+-----------------------------------------------------------
 MsySmsy |  1000   1366831  -142497.4  2.03e+07  -2.47e+07  2.75e+07  (N)
         |                                        909136.9   3574407  (P)
         |                                        942767.5   3874547 (BC)
---------------------------------------------------------------------
                   N = normal, P = percentile, BC = bias corrected
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Bootstrap statistics for Fraser River chum salmon

```
Variable  | Reps  Observed      Bias  Std. Err.  [95% Conf. Interval]
----------+--------------------------------------------------------
OptimalH  | 1000  .4549801 -.0111754  .0606369   .3359899 .5739704  (N)
          |                                      .3187582 .5584596  (P)
          |                                      .3383276 .5682237 (BC)
----------+--------------------------------------------------------
 rickera  | 1000  1.070352 -.0259185  .1713422   .7341198 1.406583  (N)
          |                                      .7076176 1.385772  (P)
          |                                      .7568502 1.417915 (BC)
----------+--------------------------------------------------------
 rickerb  | 1000   1737787   3789289  1.07e+08  -2.08e+08 2.11e+08  (N)
          |                                     -1.12e+07 1.99e+07  (P)
          |                                     -8918146  2.70e+07 (BC)
----------+--------------------------------------------------------
    Smsy  | 1000  738690.3   1646833  4.62e+07  -8.99e+07 9.14e+07  (N)
          |                                     -4929750   8871265  (P)
          |                                     -3889967  1.20e+07 (BC)
----------+--------------------------------------------------------
    Smax  | 1000   1623566   4088124  1.11e+08  -2.16e+08 2.20e+08  (N)
          |                                     -1.40e+07 2.67e+07  (P)
          |                                     -1.15e+07 3.25e+07 (BC)
----------+--------------------------------------------------------
    Rmax  | 1000   1741900   3814411  1.07e+08  -2.08e+08 2.11e+08  (N)
          |                                     -1.13e+07 2.08e+07  (P)
          |                                     -9295692  2.55e+07 (BC)
----------+--------------------------------------------------------
 MsySmsy  | 1000   1366831   2797519  7.97e+07  -1.55e+08 1.58e+08  (N)
          |                                     -7625718  1.36e+07  (P)
          |                                     -7180628  1.53e+07 (BC)
-------------------------------------------------------------------
                N = normal, P = percentile, BC = bias corrected
```

Bootstrap statistics for Clockwork wild chum salmon.

```
Variable  | Reps  Observed     Bias     Std. Err.  [80% Conf. Interval]
---------+-----------------------------------------------------------------
OptimalH | 1000  .4352859 -.0202798  .101778   .3047658  .565806  (N)
         |                                     .2786603 .5341458  (P)
         |                                     .2893046 .5422705 (BC)
---------+-----------------------------------------------------------------
rickera  | 1000  1.014725 -.0415576 .2748791   .6622204  1.36723  (N)
         |                                     .6092941 1.307704  (P)
         |                                     .6350737 1.333487 (BC)
---------+-----------------------------------------------------------------
rickerb  | 1000   2659544  -1788173 8.06e+07  -1.01e+08 1.06e+08  (N)
         |                                      1706945  5960297  (P)
         |                                      1970618  9265719 (BC)
---------+-----------------------------------------------------------------
    Smsy | 1000   1140863 -808257.4 3.66e+07  -4.58e+07 4.81e+07  (N)
         |                                     696054.4  2649921  (P)
         |                                     812001.1  4212481 (BC)
---------+-----------------------------------------------------------------
    Smax | 1000   2620950  -2645280 1.24e+08  -1.56e+08 1.61e+08  (N)
         |                                      1122802  7864144  (P)
         |                                      1552659 1.40e+07 (BC)
---------+-----------------------------------------------------------------
    Rmax | 1000   2659830  -1909188 8.74e+07  -1.09e+08 1.15e+08  (N)
         |                                      1730178  6193497  (P)
         |                                      1987808  8996702 (BC)
---------+-----------------------------------------------------------------
 MsySmsy | 1000   2036482  -1168018 5.23e+07  -6.50e+07 6.91e+07  (N)
         |                                      1380526  4006734  (P)
         |                                      1479129  4551206 (BC)
---------------------------------------------------------------------------
                   N = normal, P = percentile, BC = bias corrected
```

Bootstrap statistics Wild Clockwork Chum Salmon

```
Variable  | Reps  Observed     Bias   Std. Err.  [95% Conf. Interval]
---------+----------------------------------------------------------
OptimalH  | 1000  .4352859  -.0164635  .0964149   .246087  .6244848 (N)
          |                                      .1904065   .574699 (P)
          |                                      .2017107  .5803051 (BC)
---------+----------------------------------------------------------
rickera   | 1000  1.014725  -.0324458  .2613436  .5018798  1.527571 (N)
          |                                      .4036203  1.439501 (P)
          |                                      .4292128  1.458367 (BC)
---------+----------------------------------------------------------
rickerb   | 1000   2659544  979964.5  2.51e+07  -4.66e+07  5.19e+07 (N)
          |                                     -1.03e+07  1.40e+07 (P)
          |                                      -3783315  4.57e+07 (BC)
---------+----------------------------------------------------------
Smsy      | 1000   1140863  452894.9  1.14e+07  -2.13e+07  2.36e+07 (N)
          |                                      -4773016   6430002 (P)
          |                                      -1650017  2.69e+07 (BC)
---------+----------------------------------------------------------
Smax      | 1000   2620950   1814723  4.07e+07  -7.72e+07  8.24e+07 (N)
          |                                     -1.85e+07  2.21e+07 (P)
          |                                      -7417545  8.53e+07 (BC)
---------+----------------------------------------------------------
Rmax      | 1000   2659830   1155487  2.78e+07  -5.19e+07  5.72e+07 (N)
          |                                     -1.16e+07  1.57e+07 (P)
          |                                      -5605923  4.59e+07 (BC)
---------+----------------------------------------------------------
MsySmsy   | 1000   2036482  615245.3  1.62e+07  -2.98e+07  3.39e+07 (N)
          |                                      -6266749   9351173 (P)
          |                                      -4164947  1.93e+07 (BC)
--------------------------------------------------------------------
                  N = normal, P = percentile, BC = bias corrected
```